

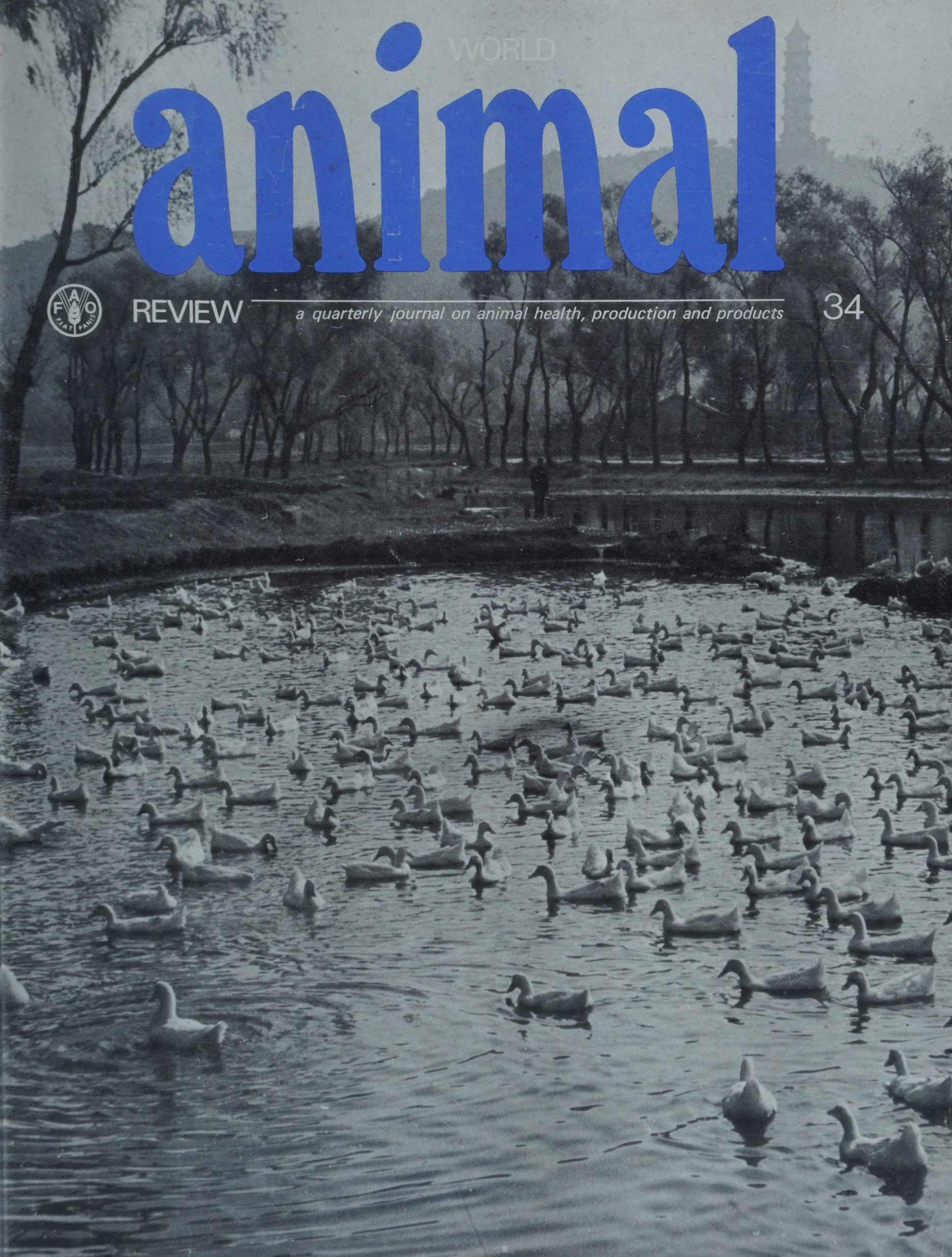
WORLD animal



REVIEW

a quarterly journal on animal health, production and products

34



Animal draught power

In Southeast Asia, the Near East and in certain Mediterranean countries the use of draught animals continues to be the dominant factor in the cultivation of the soil. In many parts of tropical Africa, however, even though the numbers of potential draught animals are large, the position is quite different.

In the latter case crop cultivation and animal husbandry have traditionally been carried out by two distinct groups in the rural population — the crop cultivators generally working on the basis of shifting cultivation, and the stock raisers, knowledgeable regarding the herding of their stock, often on a nomadic or transhumant basis, but ignorant of how to train their animals for, or use them with, agricultural implements.

Farming carried out on the basis of hand-tool technology seldom exceeds a subsistence level. The area that can be cultivated by a family is limited generally to not more than 2 ha. The only power available is from the farmer and his family and their entire effort is normally needed just to produce food for their own use. Only in occasional "good" years is there a surplus that can be marketed and this is insignificant in relation to the present and projected requirements for increased production of food for an expanding population. About a quarter of the cultivated area in developing countries falls into this category of farming.

Farming on the basis of animal-draught technology is characteristic of about half of the cultivated area in developing countries. Most of the farms in this category are above the subsistence level and the marketable surplus from them provides much of the present food supply for urban dwellers.

Mechanical power technology is used on about a quarter of the cultivated land in developing countries. Most of the output from this category of farm is going into commercial marketing channels and provides a significant portion of the food requirements of the non-agricultural population as well as most agricultural exports.

Present levels of land and labour productivity in most developing countries are not adequate to meet either present or projected food needs. To overcome these and other problems greater attention will have to be given to the small farmers who make up the bulk of the farm population in developing countries. A comprehensive approach to the improvement of technology on the farm is required, including the introduction of progressively higher levels of mechanization. Hand-tool technology needs to be supplemented, therefore, with animal-draught technology where this is feasible and appropriate.

Before the events of the last few years, which brought a steadily increasing realization that oil was a rapidly diminishing asset and, in any case, one likely to become increasingly more expensive, efforts were being made in many developing countries to develop the use of the tractor for agricultural operations.

Few farmers had either the capital funds available, the minimum mechanical competence or the experience of intensive cultivation methods that would have enabled them individually to purchase tractors. Even governments encountered difficulties in finding the hard currency resources necessary for importing such equipment. In spite of these difficulties relatively large numbers of tractors were brought into use by co-operatives or government organizations and used on farmers' land on a repayment basis.

With the heavy burden of high fuel charges, often payable in hard currencies, and fuel shortages, many developing countries are having difficulty implementing plans for the power mechanization of their agriculture. The use of their animal resources, if they are fortunate enough to have them for use in agricultural production systems and for non-agricultural use in load carrying, therefore now assumes a much greater importance than before.

The ownership of suitable types of animals, however, will not in itself be enough. Credit will be needed by farmers to purchase animals and equipment. Intensive-training schemes will need to be developed and implemented for the training of the farmer in the care and use of his animals, as will extension services, which will be required by the farmer as he accustoms himself to new farming methods and techniques.

Considerable scope exists for improving animal-draught equipment and tools and the matching of implements to specific farming situations. Conditions in different countries vary greatly so that each country will need to devote efforts to securing implements appropriate to its conditions and to the capacity of its farmers to use them. Furthermore, even simple equipment needs maintenance and spare parts.

An FAO publication that is likely to be in increasing demand is the *Manual on the employment of draught animals in agriculture*. This manual was originally produced by the French Research and Experimental Centre for Tropical Mechanical Agricultural Equip-

WORLD animal

REVIEW *a quarterly journal on animal health, production and products* no. 34 - 1980

Animal power in agricultural production systems F.M. INNS	2
The Pekin duck in China YI JUNG and YU-PING ZHOU	11
Crocodile management in Papua New Guinea M. BOLTON	15
Sheep and goat production in the drought polygon of northeast Brazil I.L. MASON	23
Beekeeping in Tunisia - its impact on other developing countries of the Mediterranean basin A. POPA	29
Dried poultry waste as a feed ingredient J. BIELY, W.D. KITTS and N.R. BULLEY	35
Short communication The location of literature on rabbit research D.D. CAVENY and H.L. ENOS	43
News and notes	45
Publications	46

WORLD ANIMAL REVIEW is a quarterly journal reviewing developments in animal production, animal health and animal products, with particular reference to these spheres in Asia, Africa and Latin America. It is published by the Food and Agriculture Organization of the United Nations. FAO was founded in Quebec, Canada, in October 1945, when the Member Nations agreed to work together to secure a lasting peace through freedom from want. The membership of FAO numbers 147 nations.

Director-General: Edouard Saouma

WORLD ANIMAL REVIEW [abbreviation: *Wild Anim. Rev.* (FAO)] is prepared by FAO's Animal Production and Health Division, which is one of five divisions in the Agriculture De-

partment. The Division is subdivided into three technical services concerned with animal production, meat and milk development, and animal health.

Chairman of the Editorial Advisory Committee: H.C. Mussman (Director, Animal Production and Health Division).

Acting Technical Editor: D.E. Faulkner.

Layout: D. Grauer.

● The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation

of its frontiers or boundaries. ● The views expressed in signed articles are those of the authors. ● Information from **WORLD ANIMAL REVIEW**, if not copyrighted, may be quoted provided reference is made to the source. A cutting of any reprinted material would be appreciated and should be sent to the Distribution and Sales Section of FAO. ● Subscription rate for one year: US\$8.00. Rates can be paid in local currencies when orders are placed through the authorized sales agents listed on the back cover. Subscriptions and inquiries may also be addressed to: Distribution and Sales Section, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

COVER: At the foot of Mount Yu-Quan, the place of origin of the Pekin duck.

Animal power in agricultural production systems

with special reference
to Tanzania

F.M. Inns

The input of mechanical energy under the control of man is a fundamental feature of all agricultural systems. It distinguishes agricultural production from the "hunting and collecting" subsistence economy, which is practised by only very few people in the world today.

Machinery is the means by which mechanical energy is transmitted, under control, so as to perform a desired operation contributing to agricultural production. This is the basis of mechanized farming, illustrated very simply in Figure 1. The diagram emphasizes the two essential components of mechanized farming, *mechanical energy* and *machinery*.

Mechanical energy is used when forces are applied to an object to do work. Most commonly in agricul-

The author is Professor of Agricultural Engineering at the University of Dar-es-Salaam, PO Box 35091, Dar-es-Salaam, Tanzania. This article is based on a paper presented to the Sixth Scientific Conference, Tanzanian Society of Animal Production, Iringa, held in May 1979. It is published by courtesy of the Agricultural Mechanization Group of Agricultural Services Division, FAO.



At an agricultural training centre, Upper Volta, where, assisted by an FAO/UNDP project, oxen are trained for land cultivation — a technique previously unknown in Upper Volta



Bullocks drawing cultivator for preparation of seedbed for millet production in Niger

TABLE 1. Comparison of characteristics of a tractor and a pair of oxen

Feature	Tractor (50 kW)	Pair of oxen (1 kW)
<i>Costs¹ (TSh)</i>		
Initial cost	125 000.00	4 000.00
Total cost per hour of use (based on 500 hours/year usage)	165.00	5.95
Foreign exchange cost per hour of use	80.00	0.40
Cost per kWh	3.30	5.95
Foreign exchange cost per kWh	1.60	0.40
<i>Work capability</i>		
Maximum pull (kN)	6	1
Maximum speed for field work (m/s)	3	1
Potential work per day (h)	24	5
<i>Miscellaneous</i>		
Replacement	High foreign exchange cost	Self-perpetuating as a species
Maintenance requirement	Skilled artisans	Sympathetic farmer and veterinarian sometimes
Management level required	High for effective use	Moderate

¹ See Table 2 for calculations.

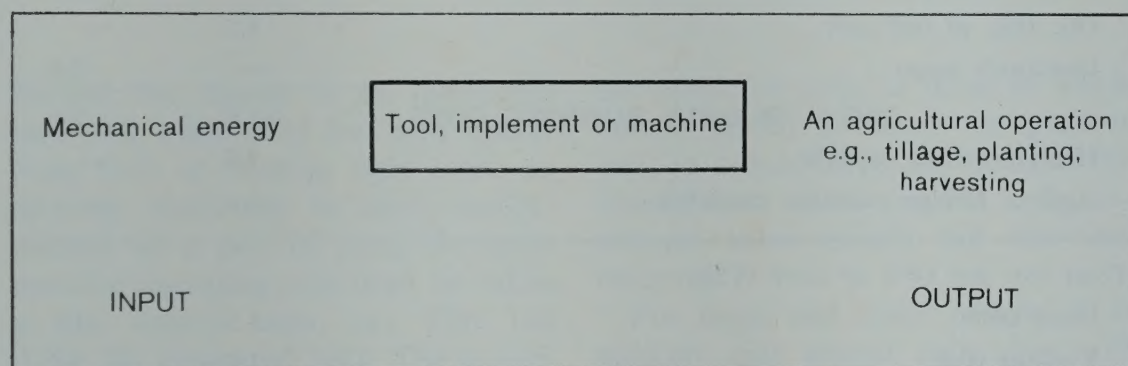


Figure 1 Fundamental diagram of a mechanized farming operation

ture the forces are intermittent when provided by man, for example, in hoeing or digging, or continuous when provided by an animal or tractor, such as in pulling a plough or other implement.

For all practical purposes there are only three power sources available for field operations: a human, an animal and a heat engine (petrol or diesel).

These are the only power providers that have a concentrated and hence portable fuel supply. This is essential for field operations that involve mobility and the covering of an extensive area. It is a matter of some

interest that each of these power providers is activated by the same basic chemical process — oxidization of the fuel supply.

This article is concerned with the use of animals as a source of power for agricultural operations.

Why use animal power?

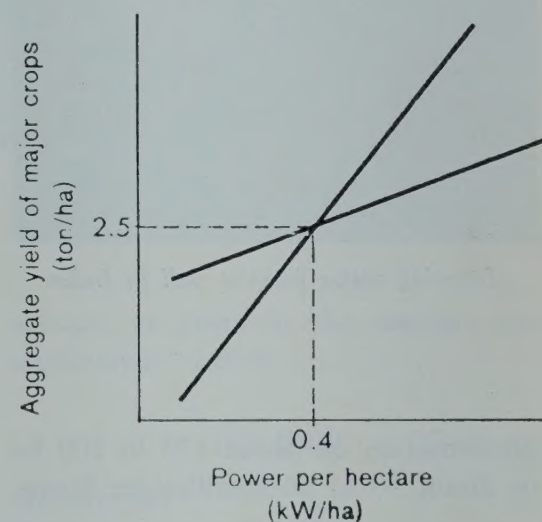
POWER AND AGRICULTURAL DEVELOPMENT

Giles (1975) analysed available statistics and established a correlation



(PHOTO: WFP)

Ploughing newly irrigated land with oxen in front of the colossi of Mennekes in Egypt

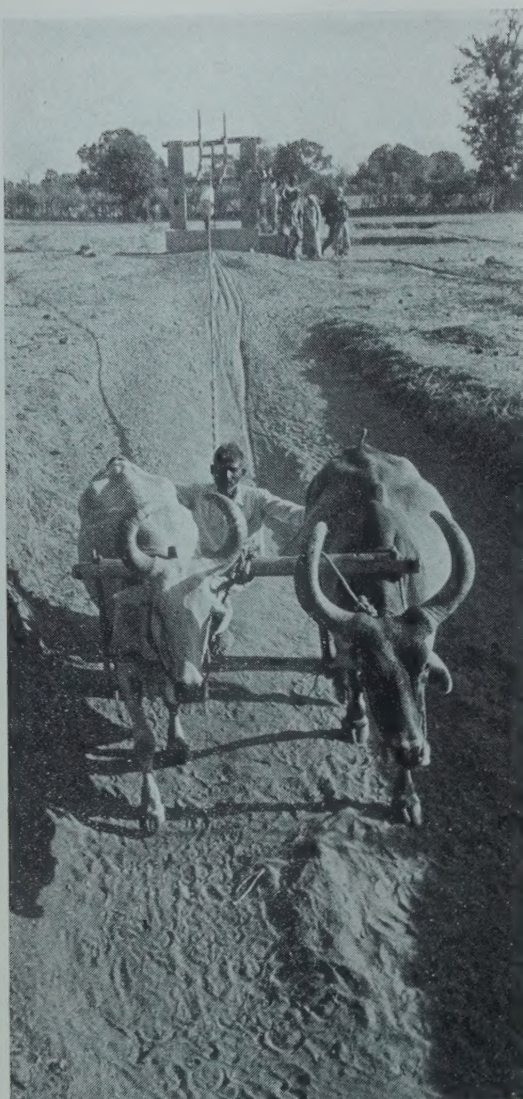


(SOURCE: GILES, 1975)

Figure 2 The relationship between power inputs and crop outputs in agricultural production

between available power per hectare and crop yield, as shown in Figure 2.

This indicates a high rate of increase of yield for increasing power inputs up to a level of approximately 0.4 kW/ha (corresponding to crop output of about 2.5 ton/ha). Typically in Africa one adult works about half a hectare of land, providing a power input of about 0.1 kW/ha. If 0.4 kW/ha is taken as a desirable level then supplementation by about 0.3 kW/ha is necessary. A pair of work oxen would provide such supplementation for about 3 to 4 ha of land, i.e., about one smallholder farm. A 50-kW tractor would provide sup-



Drawing water from a well in India

plementation on about 150 to 200 ha or about 30 to 60 smallholder farms.

ANIMALS OR TRACTORS?

The managerial problems of using one tractor in activities on 40 or more farms are difficult to overcome. Many methods of achieving "multifarm use of agricultural machinery" have been proposed and tried (Lonnemark, 1967), including hire schemes and grouped and co-operative farms, but with little success to date. Ownership and care of a pair of work animals presents a more feasible solution, and has been proved to be practicable in many countries where power inputs are low.

Some of the characteristics of a typical tractor and of an animal draught unit (in this case a pair of oxen), are compared in Table 1.

The high cost of tractor use, at TSh 165 (US\$ 20) per hour, may sur-

TABLE 2. Cost calculation for a 50-kW tractor and a pair of oxen

Item	Tractor	Pair of oxen
Power (kW)	50	1
Initial cost (TSh)	125 000	4 000
Economic length of service (years)	5	5
Salvage value (% of initial cost)	20	80
Salvage value (TSh)	25 000	3 200
<i>Calculation of fixed cost per annum (TSh)</i>		
Depreciation	20 000	160
Interest at 6%	4 500	216
Insurance at 3% initial cost	3 750	120
Housing	1 000	160
Maintenance feed: 3.2 feed units per day at TSh 0.20/ feed unit	—	468
Management: 125 man-hours/year at TSh 2/man-hour	—	250
Veterinary care	—	400
Drivers' wages	7 200	—
TOTAL FIXED COST/YEAR	36 450	1 774
Annual cost per kW	729	1 174
Approx. foreign exchange cost per kW per year	400	200 ¹
<i>Calculation of hourly running cost at 500 hours/year (TSh)</i>		
Spares and repairs	75	—
Supplementary work feed	—	0.4
Fuel: 6 l at TSh 2.50/litre	15	—
Oil: 10% of fuel cost	1.5	—
Operator's wages	—	2.0
TOTAL HOURLY RUNNING COST	91.5	2.4
Hourly running cost/kW	1.8	—
Approx. foreign exchange cost/kWh	0.8	—
<i>Total cost per kWh of work (TSh)</i>		
Fixed costs	1.5	3.6
Running cost	1.8	2.4
TOTAL	3.3	6.0
Approx. foreign exchange component	1.6	0.4
<i>Summary</i>		
<i>Cost per hour</i>	(TSh)	
50-kW tractor	165	
Pair oxen	6.0	
<i>Approx. foreign exchange cost per hour of use</i>		
50-kW tractor	80	
Pair oxen	0.4	
<i>Cost per kWh</i>		
50-kW tractor	3.3	
Pair oxen	6.0	
<i>Approx. foreign exchange cost per kWh</i>		
50-kW tractor	1.6	
Pair oxen	0.4	

¹ Cost of medicines.

Source: Have and Dihenga (1979).

prise many but its detailed costing is given in Table 2. This compares with a cost of TSh 6 (US\$ 0.72) per hour for a pair of draught oxen. The cost per unit of energy (kWh) supplied shows the tractor in a more favourable light, being little more than half the cost per unit of energy from a pair of oxen. However, two points should be borne in mind. First, the foreign exchange cost per unit of tractor energy is four times that for oxen.



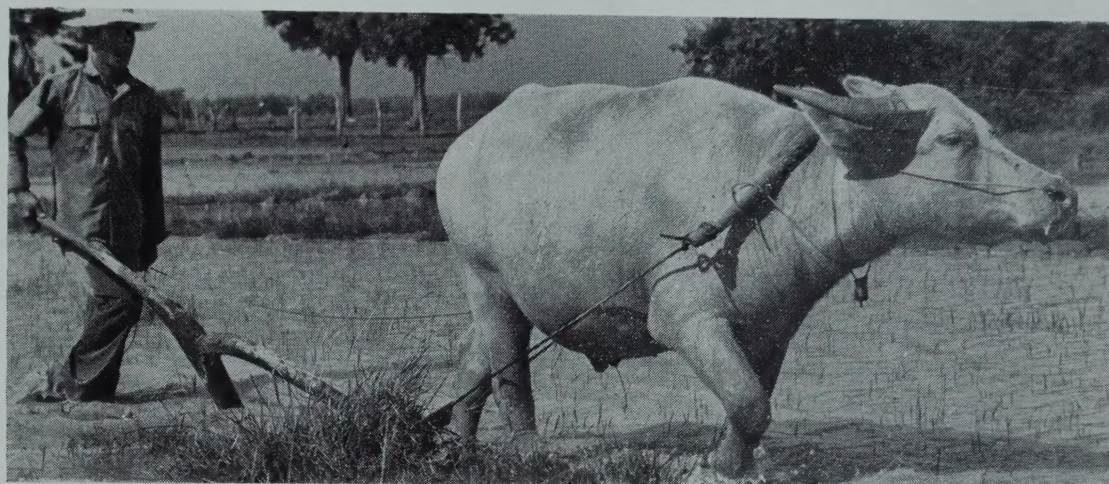
Turning a water wheel for irrigation in India

CEEMAT (Centre d'étude et d'expérimentation du mécanisme agricole tropical) and based on African experience (mainly in West and Central Africa). The manual gives detailed guidance on such matters as animal care, training, housing, feeding and methods of harnessing, as well as implements suitable for their use.

The characteristics of the four animals mentioned above together with the arguments for and against each



Newly trained for the cart in Benin



Ploughing paddy with a buffalo in the Lao People's Democratic Republic

Second, the tractor is an indivisible unit and when used for light operations such as hauling light loads or mowing, which can be easily accomplished by a pair of oxen, the comparative operating cost must be taken at the hourly rates, i.e., TSh 165 (US\$ 20) compared with TSh 6 (US\$ 0.72). Fifty pairs of oxen allow a considerably greater flexibility of deployment than one tractor.

All in all the conclusion is inescapable that economically the balance of advantage lies with the oxen, particularly in a country where foreign exchange is not easily available, farm size is modest, and labour supply not a limiting factor in areas of good, cultivable land.

One major problem frequently stands in the way of animal-powered mechanization. In areas where there is no tradition among arable farmers of animal ownership and care, it is extremely difficult to instil into them the necessary management skills and the confidence and sympathy that the use of animals demands. These areas

are often the same as those in which animal health problems are greatest and, in consequence, the demand for management skills highest. Tsetse-infested areas usually fall into this category.

For these and other reasons it is unlikely that animal cultivation will be a feasible solution to problems of mechanization in areas of this kind, and thus alternative engine power for them has to be sought.

Characteristics of draught animals and methods of using them

CHOICE OF SPECIES

Many animals have been used for draught work or transport, the principal being horses, oxen, water buffaloes, donkeys, camels, mules and goats. The choice between horses, oxen, donkeys and camels is well summarized in an FAO manual (FAO, 1972) originally published by

species, as given in the manual, are summarized below.

The horse

Advantages

- It is a friendly animal that becomes attached to its owner.
- It enjoys a certain prestige in Africa, so that the farmer is inclined to give it greater care than he would an ox.
- It is easy to train for all kinds of work.
- When working, it is fast, easy to handle, docile and can be simply, easily and accurately controlled.

Disadvantages

- It is often too light in Africa, where, under average conditions of maintenance, its weight may be 250 to 280 kg.
- It has a rather weak constitution and needs special care and attention and is costly to maintain.
- It is susceptible to trypanosomiasis.

- It tires fairly quickly when working.
- It is expensive.
- Its harness is costly.

The ox

Advantages

- It works slowly but unflaggingly.
- It is hardy and strong and easy to feed.
- Its harnessing is simple and the yoke can be made locally at low cost.
- Its purchase price is attractive (in some countries 1 pair of oxen = 1 horse).
- At the end of its working life, it may be sold for meat, and is in fact often sold for this purpose after a period of fattening.

Disadvantages

- It is not a friendly animal, at least so far as many African farmers are concerned who are unaccustomed to the care of animals. The farmer considers the ox solely from the point of view of its working value.
- The ox needs relatively extensive grazing areas.
- It appears to be more difficult to train than the horse and needs more manpower to control it.
- When working, it is slow.

The donkey

Advantages

- It is a friendly, hardy and quiet animal.
- It is economical to buy and can be maintained on local farm produce.
- It is easy to train and is intelligent.
- It is patient when working (light draught work and load carrying).

Disadvantages

- It is very light and limited in strength.
- It tires easily if driven too fast.
- It is susceptible to trypanosomiasis and harness sores.

The dromedary

This animal is patient and hardy but difficult to train and sometimes has an awkward temperament.

TABLE 3. Work potential of man, various animals and a 50-kW tractor

Item	Man	Horse	Ox	Donkey	Tractor
Pull (N)	—	500	500	400	10 000
Speed (m/s)	—	1.0	1.0	1.0	2.5
Power (kW)	0.20	0.50	0.50	0.40	25
Daily work hours (h)	6	6	5	4	8-24
Daily work output (MJ)	4	10	9	6	720-2 160

CHOICE OF BREED

It needs to be stressed that in most cases and whenever possible, use should be made of local indigenous breeds. The use of animals transferred within the country or imported animals should be avoided.

CHOICE OF INDIVIDUAL

Within a particular species or breed, the qualities to be looked for when choosing a draught animal are as follows:

Conformation. As regards the ox, as a draught animal, it should be powerful, compact, sturdy with well-developed muscles, particularly those of the back and the hindquarters. Its legs should be strong and as short as possible ("low on the ground"). Its chest should be ample and deep.

In the case of draught horses, they should have, in addition to the same power characteristics as the ox, short and straight shoulders, as long forelegs and as strong muscles as possible (for

leverage), sloping hindquarters and short hindlegs.

Character. Whatever the species, a calm and docile animal without vices (tendency to kick or to butt) should be sought.

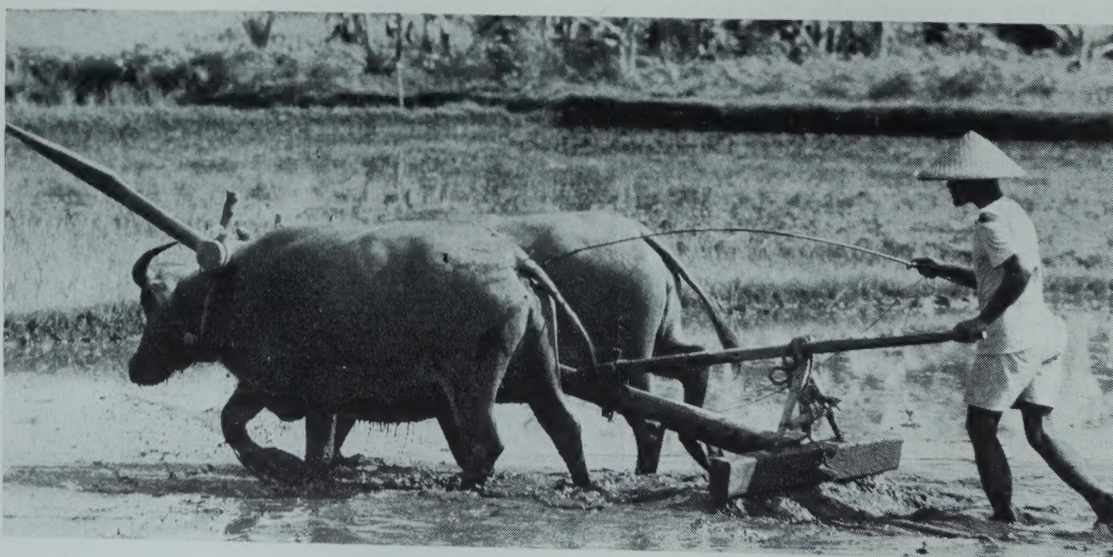
Age. In the case of the ox, training starts at about two or three years of age; in the horse, at about three years.

Sex. Gelded males are usually used but the mare, the she-ass and the cow can also be used.

UTILIZATION AND WORK TO BE DONE

The ox. The ox is particularly suitable on fairly heavy soil, for relatively deep work (15 cm), for lifting groundnuts, digging-in green manure, pulling loaded carts and drawing water from wells.

The horse. The horse is mainly used on light soil for shallow row-crop work (such as for groundnuts, sorghum



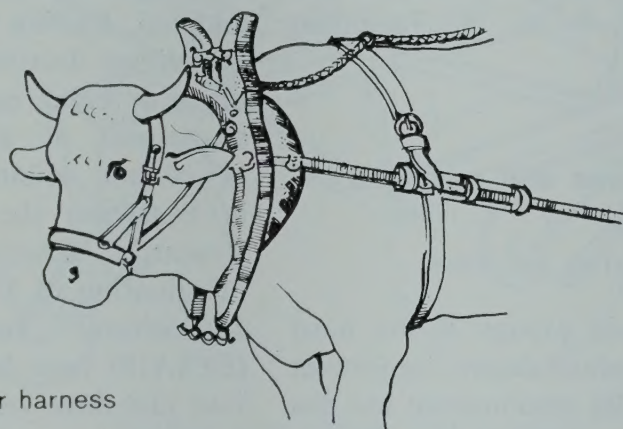
Cultivating rice with buffalo in Indonesia



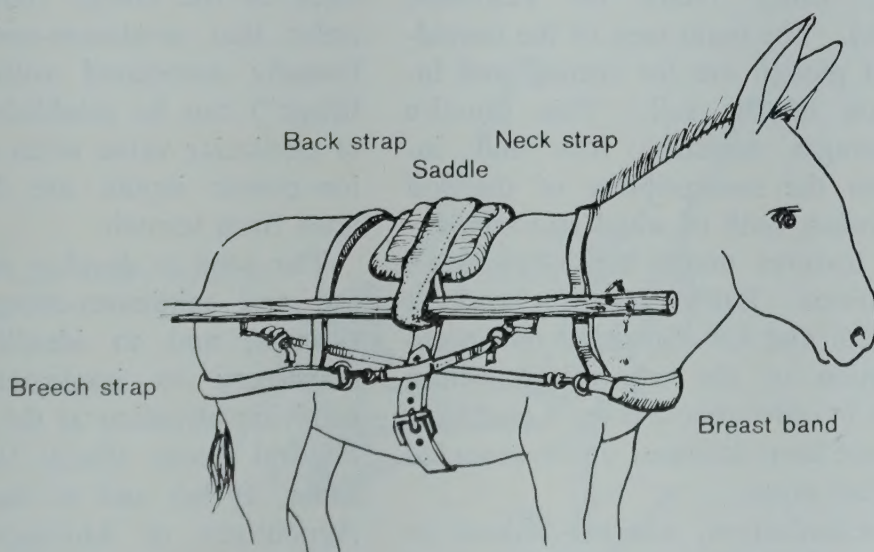
Single neck yoke (China)



Double neck yoke (India)



Ox with collar harness



Donkey with breast band harness

Figure 3 Various types of harness

and millet), and for pulling the seeder or the light hoe. No other animal can compare with it for pulling light, shafted carts or cabs but it is not usually strong enough (at any rate in Africa) for ploughing or pulling the groundnut lifter.

The donkey. The donkey is suitable for light draught work and load carrying, and light work, such as weeding, hoeing, sowing or the use of the single row planter.

The dromedary. The dromedary is used mainly as a beast of burden and, in arid regions, for drawing water.

There is little doubt that for draught purposes in Tanzania the immediate choice is narrowed down to oxen and donkeys, although the possibility of employing mules might also be explored as the opportunity arises.

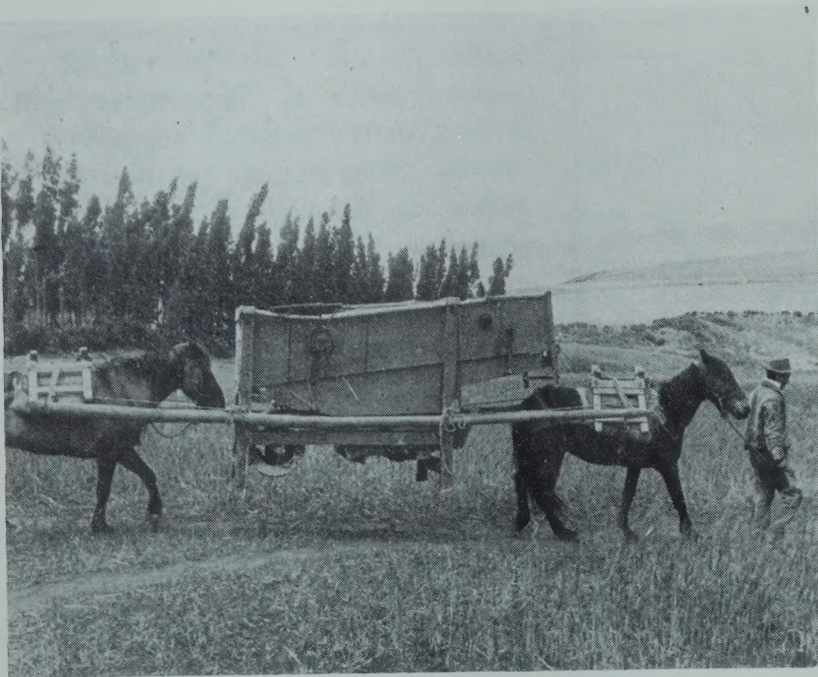
WORK POTENTIAL

Table 3 shows the work capacity of man, various animals and a 50-kW tractor in terms of mechanical power and work output. The data available are somewhat variable, as may be expected for different breeds and for the varying condition of the animals and of the environment in which they are found. The values in the table may, therefore, be used for general guidance and comparison, but should be applied with discretion. The pull and power quoted for animals are based on figures for continuous work output. For short periods they can be greatly exceeded (by a factor of five or more) if compensated by adequate rest periods.

HARNESSES

Harnesses for work animals fall into three broad categories — yoke, collar or breastband. Some examples are illustrated in Figure 3.

Basically the yoke is a wooden cross-piece to which the animal applies a pushing force from the forehead (head yoke) or neck (neck yoke). The yokes may be either single or double. There are very many regional variations in design (Hopfen, 1969). The double neck yoke is the most widely



Horses carrying agricultural equipment in Ecuador



Donkeys used in pulling carts in Upper Volta

used method for harnessing oxen, being simple to make, cheap and effective. Its suitability for oxen rests on the fact that oxen are strong shouldered but rather weak across the breast.

In contrast the main strength of horses and donkeys is in their breast and shoulders. For high pulls a collar harness is most suitable. This should be adapted to the individual animal so that it is well-fitting. It must be padded with a soft lining.

For lighter work a breastband may be used with horses and donkeys, but not oxen. The illustration shows a full breastband harness for use in pulling a cart. Simpler types consisting essentially of a breastband and neckstrap only may be used in other cases.

CONTROL

The accuracy and quality of work performed by draught animals is greatly influenced by ease and effectiveness of control. Ideally the operator should be able to guide both the implement and the animal, dispensing with a separate lead man.

Control depends on an effective guidance system, good training and regular practice. For oxen, guidance may be by means of ropes attached to the ears, horns or nose of the animal. In the latter case the nasal

septum must be pierced for the purpose. Uyole Agricultural Centre recommend the insertion of a screwed ring into the nose and have provided details of the training and methods of harnessing found effective at the Centre (Daily News of Tanzania, 1978a).

Farm systems and machinery

FARMING SYSTEMS

The mouldboard plough is the most widely used animal-drawn implement in Tanzania. Its predominant use has been frequently criticized (e.g., Beeny, 1975; Daily News of Tanzania, 1978b). The main uses of the mouldboard plough are for cutting and inversion of the soil. This practice encourages moisture loss and increases the susceptibility of the soil to erosion, both of which are undesirable features under most Tanzanian conditions. Earlier research work at Tengeru and Ukuriguru on the mechanization of the wheat and cotton crops in order to avoid these problems has not been followed up or extended to other crops.

Mechanization, whether animal or tractor powered, has too often been approached without sufficiently considering the farming practices and cultivation techniques required for the

most efficient and effective work that meets the crop requirements of given areas under their prevailing environmental conditions. The farm machinery available has been allowed to dictate the system of cultivation adopted, leading to sub-optimal, and sometimes disastrous results. Efforts are now being made to make a true assessment of the machinery needs of certain countries. For example, in Botswana the "Dryland Farming Research Scheme" (DLFRS) and "Evaluation of Farming Systems and Agricultural Implements Project" (EFSAIP) have been in operation for four and three years respectively. This approach is coupled with a full assessment of the energy requirements in order that minimum-energy systems (usually associated with "minimum tillage") can be established. This is of particular value when systems with low-power inputs are being developed from scratch.

The need to develop minimum tillage and minimum-energy-production systems, and to identify the farm machinery to implement them, is receiving attention at the Uyole Agricultural Centre (Daily News of Tanzania, 1978c) and at the Faculty of Agriculture at Morogoro (Dihenga and Have, 1979; Have and Dihenga, 1979). The work is relevant to both animal- and tractor-powered systems. Further projects in this field are cur-

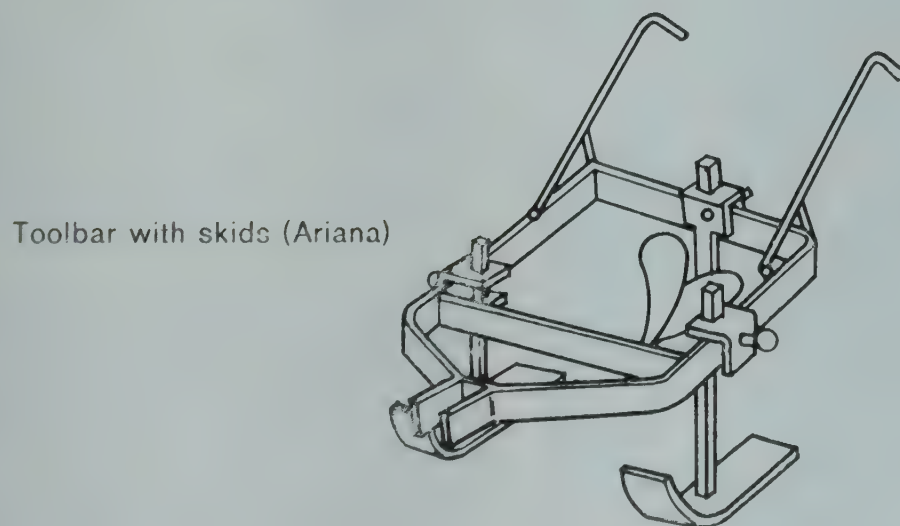
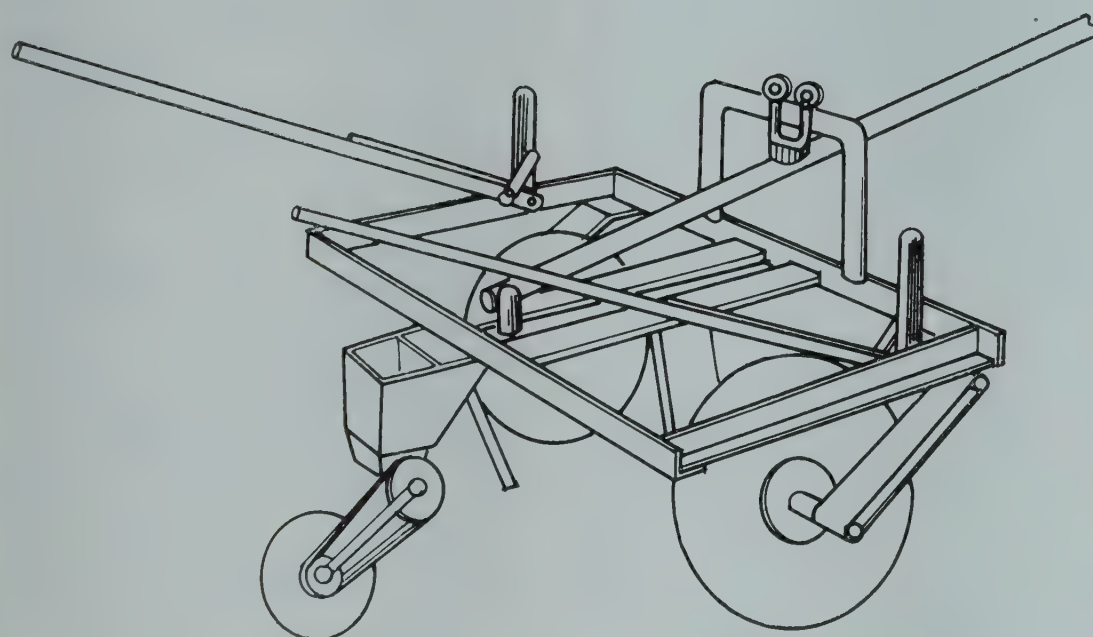
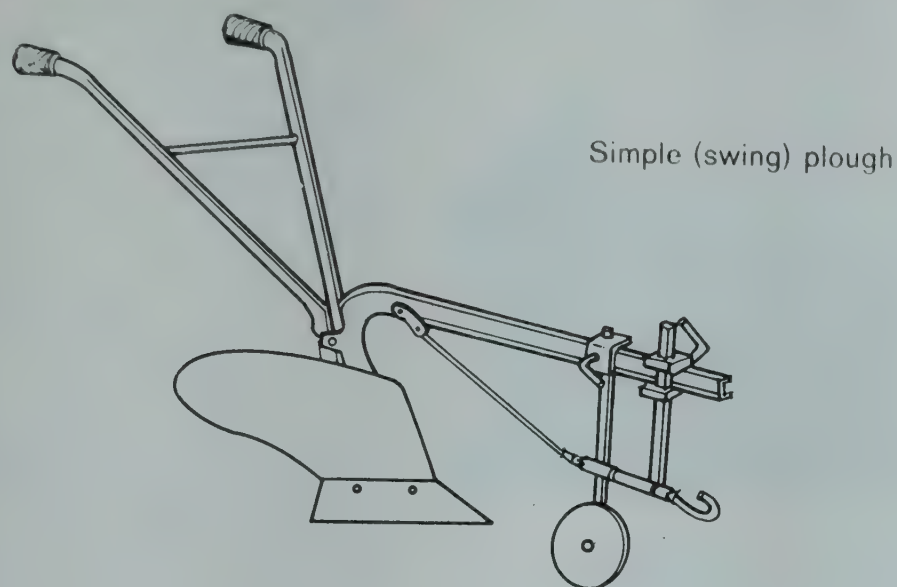


Figure 4 Categories of animal drawn equipment

rently receiving attention within the Ministry of Agriculture.

Economic and social considerations also affect the formulation of a suitable farming system, and are additional to the technical considerations mentioned above. Conditions and crops vary widely from place to place and circumstances vary with time so that no one solution is universal or permanent, and an "optimum" solution is neither likely nor lasting. The aim must be to approach the optimum more closely than hitherto and be prepared to recognize flaws and make improvements. The recommended system must be robust as an insurance against such uncertainties as climate and market prices. A delicately poised optimum is unlikely to survive under present conditions.

MACHINERY

Machinery is required to support the farming system that has been formulated and not the other way round. The farming system is the dog and machinery the tail and it is accepted practice that the dog should wag the tail. Since, in Tanzania, the necessary farming systems have not been established to a reasonable degree of certainty, it is not possible to say precisely what types and models of machinery will be required. Some points can, nevertheless, be made.

It is likely that the chisel plough and/or tine cultivator should play a more prominent role in cultivation systems where moisture conservation and resistance to soil erosion are needed. (Attention is being given to mulches for the same reason.) These implements have different operational characteristics from the mouldboard plough.

The conventional ox-drawn mouldboard plough (Figure 4a) is a "swing" plough — that is, it has no support wheels, and only a small nose wheel that assists manoeuvrability and control. Because of its shape, the mouldboard plough can be controlled relatively easily by the operator. When properly hitched and in good soil conditions the depth of work may be reduced by pressing down on the



Camel drawing an implement to eradicate Bermuda grass in Tunisia

handles and increased by raising the handles so that the share point is inclined downward to give more penetration. It is not possible to control a tined implement in this way and depth regulation by means of wheels (Figure 4b) or skids (Figure 4c) becomes necessary. "Toolbar" type implements such as those illustrated become feasible solutions from a technical and economic viewpoint. Although heavier, more expensive and less manoeuvrable than the light mouldboard plough they can be fitted with a wide range of attachments. If the system requires a selection of different implements and machines it may be cheaper to buy a toolbar with the required attachments than the individual machines for each operation.

The "systems" approach in the identification of farm machinery requirements and in the development of equipment to meet them is typified

by work in Botswana with the Makgonatsotlhe toolbar and at Uyole with a locally made timber toolbar. An intermediate stage, which has not, perhaps, been performed in these cases, is the identification of suitable equipment from already existing and often well-tried machinery. Investigations of this nature are being conducted at the Kenya Agricultural Machinery Unit at Nakuru.

TRANSPORT

Transport is an essential feature of farming systems. In many circumstances, it may be looked upon as an independent operation such as in the transport of water and firewood for domestic use. For both purposes it is surprising that the use of animals has so far been so little developed in Tanzania.

The donkey, as a pack animal, can

carry a load of up to 100 kg. Using a light cart it can pull a load of 300 kg. A pair of oxen can be used to pull a cart loaded with 2 tons. The cost of such transport is low, particularly for small loads over short distances, compared with that of a tractor and trailer.

Conclusions

- An increase in power available per hectare of cultivated land enables higher crop yields per hectare to be achieved.
- Animal power can provide the necessary supplement to human labour at low cost in foreign exchange and without the need for scarce and expensive managerial and technical support.
- Existing animal-powered cultivation systems in use in Tanzania could be improved, particularly from the point of view of moisture and soil conservation needs. Development of viable systems is a prerequisite to the identification of suitable equipment.
- Machinery can only be selected meaningfully after system requirements have been identified.
- It may be necessary to develop machinery to meet specific needs. This is best done after a full evaluation of the existing machinery available has been made.
- The greater use of animals for general village transport, as well as for farm use, needs to be investigated. ■

References

- BEENY, J. 1975. *Agricultural mechanization study*. UNDP report to the United Republic of Tanzania. Rome, FAO. FAO/AGO/DP/URT/75/018.
- DAILY NEWS OF TANZANIA. 1978a. Toward draught animal mechanization. *Daily News*, 1 June 1978, p. 4.
- DAILY NEWS OF TANZANIA. 1978b. A look at tillage tools in Tanzania. *Daily News*, 8 June 1978, p. 4.
- DAILY NEWS OF TANZANIA. 1978c. The case for crop rotation. *Daily News*, 22 June 1978, p. 4.
- DIHENG, H.O. & HAVE, H. 1979. *Direct planting (herbicide use): a preliminary note on the effects on maize production*. Morogoro, Department of Agricultural Engineering and Land Planning, University of Dar-es-Salaam. Departmental Report No. 5.
- FAO. 1972. *The employment of draught animals in agriculture*. Rome.
- GILES, G.W. 1975. The reorientation of agricultural mechanization for the developing countries: policies and attitudes, action programmes. In: *Report on the meeting of the FAO/OECD expert panel on the effects of farm mechanization on production and employment*. Rome, FAO.
- HAVE, H. & DIHENG, H.O. 1979. *Cost comparisons of reduced tillage systems in Tanzania — a concept*. Morogoro, Department of Agricultural Engineering and Land Planning, University of Dar-es-Salaam. Department Report No. 2.
- HOPFEN, H.J. 1969. *Farm implements for arid and tropical regions*. Rome. FAO Agricultural Development Paper No. 91.
- LONNEMARK, H. 1967. *Multifarm use of farm machinery*. Rome. FAO Agricultural Development Paper No. 85.

The Pekin duck in China

Yi Jung and Yu-Ping Zhou

History of the Pekin duck. The Pekin duck originated in a small level area at the foot of Mount Yu-Quan, in the northwestern suburbs of Peking. Surrounded by mountains in the north and west, this area has many artesian wells and some streams flowing through it. Historically the farmers of the area were engaged mainly in the growing of rice. As the streams, ponds and rice fields were abundant in aquatic feeds, such as small fish, shrimps, snails and water weeds, there had for long been a tradition of raising ducks and, during the past 200-300 years, duck-raising has flourished.

Peking was the capital of the three feudalist dynasties of Yuan, Ming and Ching. In order to satisfy the preference of the high officials and lords for roast duck, farmers had long conducted careful selection. Already in the Ming dynasty (1368-1644 A.D.), the Pekin duck was known as an outstanding breed with stable genetic characters. In 1873 Pekin ducks were first introduced to America from where they were transported to the United Kingdom. Owing to their excellent performance as table ducklings, and also as layers, they soon became widely distributed in many parts of the world.

General characteristics. The conformation of the Pekin duck is beautiful and well-balanced. The head is large, broad and round; the neck is relatively thick and of medium length; the body is long, with a broad back, and a full and prominent breast, and with a



Rearing the young ducks

The authors are with the Department of Animal Science, Peking Agricultural University, Peking, China.

broad, deep paunch and stern almost touching the ground. The legs are strong and short. In colour the bill, legs and web are bright orange, while the plumage is creamy white. The adult weight of the drake is 3.5-4.0 kg, while that of the duck is 3.0-3.5 kg.

Production performance. The duck matures sexually at five to six months of age when it lays its first egg. Annual egg production averages 200-220. Average egg weight is 85 to 90 g, but it may be as much as 90 to 100 g in older ducks. The eggshell is white in colour. The Pekins are hardy, with good adaptability and strong disease-resistance.

Growth rate and feed efficiency. Compared with other meat animals and table birds, the Pekin duck has the biggest feed consumption per unit of body weight. They grow very fast, body weight at eight weeks of age being almost 54 times that at hatching. Under practical field conditions, average feed conversion efficiency is 3.5 (see Table 1).

Feeding and management characteristics. Pekin roast duck has been one of the favourite dishes of the Chinese people. Most of the Pekin ducks produced are used for roasting. Because the carcasses need to be well covered with fat the ducks are traditionally finished by the unique method of force-feeding.



Breeding flock

TABLE 1. Growth rate, feed consumption and feed efficiency of White Pekin ducks (male and female)

Stage of growth	Age (weeks)	Average weight (g)	Weight gain per week (g)	Weight increment (percent)	Average feed consumption (g)		Feed conversion	
					For week	Cumulative	For week	Cumulative
Starting	0	56						
	1	150	94	168	175	175	1.86	
	2	385	235	157	480	655	2.04	
	3	760	375	97	844	1 499	2.25	2.13
Growing	4	1 170	410	54	1 045	2 544	2.55	
	5	1 565	395	34	1 177	3 721	2.98	
	6	1 900	335	21	1 256	4 977	3.75	2.70
Finishing (Force-feeding)	7	2 400	500	26	2 225	7 202	4.45	
	8	3 000	600	25	3 100	10 302	5.20	3.50

Starting period. The traditional Chinese method of feeding ducks pays special attention to the behaviour of the water fowl when bathing in water. Soon after hatching, when the down has dried, the ducklings are put in a shallow pan (40 × 80 cm), with water 0.5-1 cm deep, and allowed to drink and play for two or three minutes before being started on feed. The brooding temperature during the first three days of life is 27°-30°C; it is gradually lowered with age and at 25 days of age is 18°C.

Ducklings can be reared on a floor with litter, or on wire mesh. The density of birds has great influence on the rate of gain. The number of birds per square meter is 15-18, 10-12 and 7-10 respectively for one-, two- and three-week-old ducklings. The initial separation of the stronger and weaker ducklings into smaller groups, and again after one or two weeks, helps the less vigorous ducklings to catch up and gives a more uniform flock.

Baths and exercises for the starter ducklings. Bathing and exercises are considered necessary to promote metabolism and strengthen the constitution of the ducklings. Bathing is a physiological need of waterbirds. For that reason the ducklings are allowed to come into contact with water early in life. Three days after hatching,

they are driven into shallow ponds of 10-15°C for about 5-8 minutes. In winter, when the temperature of the duck house is kept at 26-27°C, bathing is carried out once daily at noon, but in summer bathing takes place two or three times a day. As the ducklings get older and the weather warmer, the duration of bathing is gradually increased.

Ducklings receive exercise both indoors and outdoors. Indoor exercise is done by driving the birds slowly along the walls of the duck house. Ducklings should not be allowed to lie on the wet litter for any length of time. Outdoor exercise not only strengthens the body but also exposes the ducklings to solar radiation. This reduces the number of poor feeders during the period of force-feeding.

Feeding of the duckling. The ducklings are given wet mash soon after hatching. Green feeds may be introduced into the diet after they are three days old. The ducklings relish pond-weeds and algae grown naturally in ponds and streams, including curly pond-weed (*Potamogeton crispus* L.), baby pond-weed (*Potamogeton pusi-lus* L.), fennel leaf pond-weed (*Potamogeton pectinatus* L.), hornwort (*Ceratophyllum olemersum* L.) and spiral wild celery (*Vallisneria spiralis auct-non* L.). Green feeds are excellent sources of vitamins and minerals and, being bulky in nature, they increase the capacity of the digestive tract, so that the duck is well prepared for force feeding.

Growing and finishing period. The growing stage is about from four to six (or seven) weeks of age. This is considered a critical period that has a direct influence on performance in the ensuing finishing period. The aim of this period is to produce a large and strong frame with a capacious and powerful digestive system. For this reason, the growers should be fully fed; feeding generally consists of three meals in the daytime and *ad libitum* feeding during the night. Water is provided at all times. The crude protein level of the concentrate portion of the diet is 16 percent. The ratio of green feeds to concentrate

gradually increases from 3:5 to 4:5, both on an as-fed basis. In some instances, it may be as high as 5:5 to 7.5:5.

The traditional method of rearing also emphasizes the importance of swimming and exercise in the growing period. It is considered that this will promote the development of the skeleton, muscles and feathers and give a strong and capacious feeder. However, the amount of exercise and swimming needs to be controlled, as otherwise the birds grow slowly.

Force-fattening is undertaken at six to seven weeks of age when the bird weighs about 1.8 kg or more. Force-fattening started too early is likely to produce inferior and injured ducklings while fattening started too late reduces feed efficiency. Prior to force-fattening, the birds are de-toed so as to reduce injuries due to treading or stamping on one another.

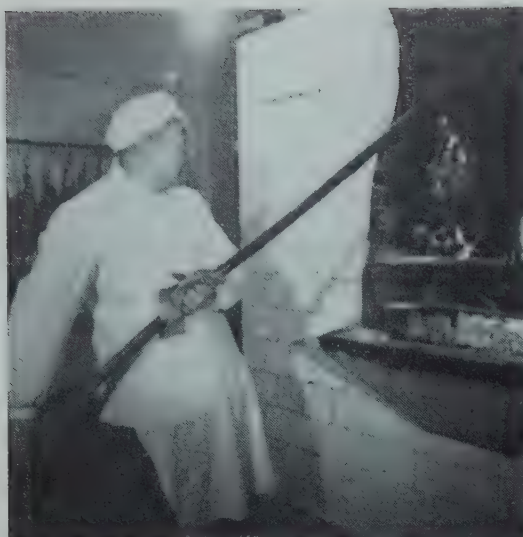
The energy concentration of the fattening diet should be about 2 800-3 200 Kcal ME/kg, with a crude protein level of 12-13 percent. Green feeds are not generally fed but some producers add 10 percent of finely chopped green feed mixed with the concentrate.

The length of the force-fattening period is in accordance with the season. In spring and autumn it takes about 10-14 days to fatten the ducklings to market weight, but in hot summers and in cold winters, it may require 15-20 days. At present, force-fattening is done mechanically. The feed is made into a paste, which is thin at first and made thicker later. The amount fed is about 150 g (water: air-dry feed = 1:1 or 1.2:1) at the beginning, gradually increasing to 300-350 g. The daily amount is given in four meals, evenly distributed over the 24 hours. Careful observation needs to be made of the digestion of the bird, and if necessary adjustment made accordingly.

The breeders. Pekin table-ducklings are produced all the year round so that hatching eggs have to be supplied at all seasons. The replacement breeder ducks and drakes are generally selected twice a year from the spring and autumn ducklings. Al-

Force-feeding young ducklings





Roast Pekin duck

TABLE 2. Comparison of carcass composition of force-fed and ad-libitum-fed ducklings

Carcass part	Force-fed (%)	Ad-libitum-fed (%)
Skin, subcutaneous fat, abdominal fat	34.70	27.90
Leg meat and breast meat	22.10	24.10
Heart, liver and gizzard	7.40	8.70
Neck, wings and webs	16.20	17.30
Head	4.40	4.70
Skeleton	11.30	12.40
Intestine	3.90	4.90
TOTAL	100.00	100.00

though Pekin ducks mature sexually and begin to lay eggs at five months of age, in practice commencement of egg laying is purposely delayed to one month later in order to raise the percentage of good hatching eggs. The method used is to restrict the energy concentration of the diet during the growing stage by including large amounts of bran and chaff and water weeds.

Swimming. All the breeders are allowed to swim in the streams or ponds for the greater part of the day when they search for food and mate freely, except in extreme weather conditions. The drakes mate more frequently in early morning and in the evening. Care has to be taken to keep off the "teaser ducks" so as to increase fertility. The streams and ponds should be rich in aquatic feeds, and not polluted by harmful industrial wastes.

Housing. Pekin ducks suffer more in hot weather than in cold weather. In summer shades should be provided in the pens, and the breeders are allowed to stay in the open air during the night. In spring and autumn the windows and doors of the breeder houses are left open, and the ducks may stay indoors or outdoors at will, but in early winter they are housed. Except in extremely cold weather, the windows are not closed. On cold mornings the windows are first opened to lower the room temperature gradually before the ducks are allowed to go out.

The breeder house is generally bedded with clean, dry sand in summer and straw in winter. As the breed ducks usually lay eggs from midnight until morning the breeder houses are provided with dim light (about 0.5 W per m²) all night, so that feed and water are visible. The floorspace requirement is about 0.4-0.5 m² per bird.

Force-moulting. Force-moulting is a characteristic feature of traditional Chinese duck-raising. To reduce loss in incubation and brooding during the hot season, the Pekin ducks are force-moulted in summer. Thus, more good-quality hatching eggs are produced in autumn, and hence more table-ducklings in winter.

Force moulting is mainly done in May and June when egg production has declined. The ducks are confined indoors. Feed is withdrawn for three days, after which it is restored to 30-40 percent of the original feed, but composed mainly of bran, chaff and water weeds. This creates the necessary stress, which soon forces the duck to stop laying and begin moulting. After about one week, the feathers on the back and breast begin to drop. Two weeks later, if the bill is beginning to turn from orange-yellow to white, the muscles of the wings are wasting away, and there is no blood when a flight feather is plucked, then the wing-bay and flights can be pulled off. The duck is plucked once every three or four days, usually three to four feathers at a time. This is done over a period of about 15 to 20 days. Then

the sickles and tail feathers are plucked. After plucking, the ducks are given a scanty diet to hasten the moulting of the remaining small feathers. A week or two later, the normal diet is gradually restored, and the ducks may be allowed to swim. About 40-50 days after plucking a new set of feathers grow out and the duck begins its second cycle of production.

In large flocks, artificial plucking is difficult when labour is scarce. A combination of feed and light withdrawal is then used to cause the ducks to drop their feathers. This latter method, however, is much slower than plucking.

Intensive duck-production. The traditional force-fattening method of fattening Pekin ducklings was developed during the long history of the well-known Pekin roast duck. Because of the changing preference of consumers for lean meat, and also in order to meet the increasing demand for export, duck raising is now changing from a system of small duck-farms into large operations of intensive production. Except for the breeders, all ducks are reared and fattened in confinement on wire mesh and are not allowed to swim. They are fed complete, dry pellets *ad libitum* without access to greenstuffs. Liveweights at eight to nine weeks of age are about the same as those under force-feeding. Feed efficiency is improved, and labour efficiency greatly increased. The carcass composition of force-fed and *ad-libitum*-fed ducklings is shown in Table 2. ■

Crocodile management in Papua New Guinea

M. Bolton

The only saleable resource available to the subsistence dwellers of the extensive swamp and riverine areas of Papua New Guinea is the crocodile. As an alternative to a complete ban on hunting (which is not practical because of supervision problems and lack of incentive to conserve the populations until it is too late) or the continuation of the present wasteful commercial system the Papua New Guinea Government has embarked on a crocodile management programme based on sustained-yield use.

To provide the necessary expertise to assist in the development of the crocodile industry, including the establishment of legislatively protected areas for use in crocodile population management, village and small business crocodile farms, larger commercial units and ancillary activities, the training of national staff, the improvement of collection, grading and marketing of skins and other assistance, the three-year UNDP/FAO-assisted project "Assistance to the Crocodile Skin Industry" (PNG/74/029) commenced operations early in 1977. This article by the Project Manager describes the experiences in crocodile management gained by the project since its inception.

At the time of the great dinosaurs there were many types of crocodile living in both fresh waters and the sea. Today zoologists classify the surviving crocodilians into three families — the true crocodiles (Crocodylidae) with 13 species, the alligators and caimans (Alligatoridae) with seven species and the Gavialidae which has a single representative in the fish-eating gharial of the Indian subcontinent. The classification is based on differences in skull, teeth and scales. All 21 species are tropical or semitropical and they do not differ significantly from their fossilized ancestors, which lived more than 160 million years ago as contemporaries of the earliest dinosaurs.

But fascinating as the group may

be from a zoological viewpoint crocodiles to most people are repulsive, frightening and useful only for their skins, which produce valuable leather. As a consequence the numbers of all species have declined drastically during the last 30 years. Much of their natural habitat — wetlands and water edge — is particularly vulnerable to human population pressure and, with a financial incentive to actively hunt crocodiles, it is scarcely surprising that in some regions people have hunted them to extinction. This annihilation has had the dual effect of pushing skin prices still higher and bringing the crocodilians to the attention of the international conservation bodies that have helped to influence policy at national government level. Nations ratifying the Convention on International Trade in Endangered Species (CITES), for example, agree to operate far-reaching trade restrictions on listed species. The lists are reviewed regularly and already include crocodilian species. Such conservation measures

are to be applauded, for they have been successful in reducing the deliberate destruction of certain wild animals (notably the big cats and other fur-bearers) not only by legal restraint *per se* but by supporting conservationists in their campaign to influence public opinion at the consumer end. Ladies wearing tiger skin coats may now expect more glances of contempt than admiration in some Western cities.

Trade bans alone will not, of course, reduce the pressure on wildlife habitat caused by expanding and increasingly destructive human populations. Nor is there always a locally convincing case for setting aside extensive areas of wildland as national park or nature reserve. Moreover it is unreasonable to expect a developing country to support a total ban on trade in a species that is not, in that country, endangered, that constitutes an important source of revenue to remote settlements and that might be harvested on a sustained-yield basis. It makes more sense, under such circumstances, to assist in bringing the trade under proper control and demonstrating the value of conservation in the sense of wise utilization. There are several alternatives and a scheme that seems most appropriate for one country may not be successful or even acceptable in another.

Crocodile biology

At this point it will be helpful to review, briefly, those biological characteristics of crocodiles that must be taken into account in any plan to produce or harvest these animals on a commercial scale. As reptiles, all crocodilians breathe air and are poikilothermic — that is, able to regulate their body temperature only to a limited degree by behavioural activities such as sunbathing, gaping and seeking shade or water. They are surprisingly easily killed by exposure to hot sun and become torpid at low temperature. In South Africa the Nile crocodile, at the edge of its range, survives the cold winters by hibernating in burrows. Blake and Loveridge (1975) consider that cold may be the most

The author is Project Manager of the UNDP/FAO project "Assistance to the Crocodile Skin Industry" (PNG/74/029), c/o UNDP, PO Box 3041, Port Moresby, Papua New Guinea. The author is grateful to his colleagues Mr R. Whitaker and Mr E.W. Balson for helpful comments on the manuscript.

important mortality factor in captive crocodiles in southern Africa.

All species are strictly carnivorous and most will eat a variety of animal material, live or dead. They will eat daily but are able to remain active for weeks without food. Not that crocodiles are normally very active animals; rather, their activity tends to be in short bursts interspersed with hours of immobility. There is evidence that, quite apart from hibernation, the metabolism can be varied enormously so as to permit, at one extreme, a fast, galloping locomotion and, at the other, submergence of an adult crocodile without breathing for over four hours.

Crocodylians lay eggs and construct a nest either by excavating a hole in the sand, like turtles, or else by piling up rotting vegetation into a mound. The number of eggs also varies with the species and it is usual for older, bigger females to lay bigger clutches. The usual range in the big crocodiles is 30 to 70 eggs, and one nest a year is the rule. A mother crocodile may guard her nest devotedly against predators but she does not incubate in the sense of providing extra warmth. In Papua New Guinea, where temperatures are consistently high, hatching occurs after about 80 days. At hatching time the young crocodiles begin to call and, at this signal, the mother unearths the eggs and has been seen to lift them out and gently crack them open in her mouth. Most hatchlings, however, emerge from the shell without this assistance. The mother crocodile may then carry the hatchlings, a few at a time, to the water if this is some distance away. It seems to be usual for the brood to remain with the mother for several days or even weeks before dispersing.

Mortality of eggs and very young crocodiles is high. Nests are commonly destroyed by flooding and many animals, such as monitor lizards, pigs, and of course people, will dig up the eggs and eat them if the parent crocodile is not on guard. With human disturbance, crocodiles will not guard their nests: the mere presence of humans at a nest site for an hour or so can cause a mother to abandon her clutch. Crocodiles are



Juvenile crocodiles can withstand crowding. Salt river (*C. porosus*) crocodiles two years old in village pen near Sepik river, Papua New Guinea.

long-lived (thought to attain 80 years of age or more) and in a full reproductive life a female could produce over 2 000 eggs. Assuming only half of these hatch, it is obvious that only a small percentage of the hatchlings survive to maturity or crocodile population growth would be explosive. Clearly the pattern is one of high productivity to allow for high early mortality. Most crocodiles in the wild die during their first year of life.

Crocodiles in Papua New Guinea and Government policies for them

Papua New Guinea has two species of crocodile: the freshwater crocodile (*Crocodylus novaeguineae*) and the so-called saltwater crocodile (*C. porosus*). Both build mound nests, often in swamp where a mound is the only practicable method of laying

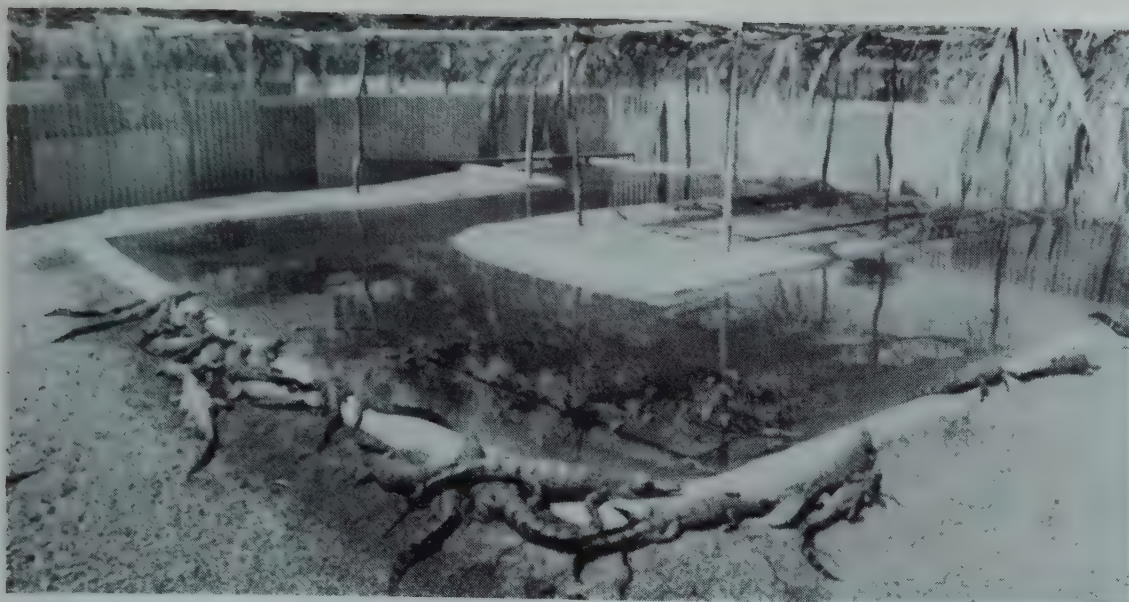
eggs above the water level. The saltwater crocodile is an exceptionally large species, adult males being said to reach 6 metres or more. *C. novaeguineae* is smaller but males can exceed 3.5 m. Both mature at about 2.5 m when, it is believed, wild specimens are about 8 to 12 years old. Both produce high-quality skins, that of *C. porosus* being particularly valuable for the flexibility and small-scale pattern of the finished leather.

As the name implies, the freshwater crocodile is found only in inland waters of Papua New Guinea and neighbouring parts of Indonesia but *C. porosus* is able to live in both seawater and freshwater and has a much wider range. Small numbers still survive in northern Australia, parts of Southeast Asia and India but over its range as a whole the saltwater crocodile is now considered to be an endangered species and is listed as such in Appendix 1 of CITES. A special exemption, however, was granted to Papua New Guinea at the last CITES meeting. This was in recognition of the fact that Papua New Guinea's crocodiles still survive in sufficient numbers to sustain a carefully managed skin industry for the benefit of rural communities that have few other resources. The Government of Papua New Guinea, with assistance from FAO, is committed to developing such an industry while safeguarding the wild crocodile populations against over-exploitation.

As mentioned earlier there are several possible management schemes and the strategy developed in Papua New Guinea may not be the one most appropriate elsewhere. In Papua New

Feeding time — village near Sepik river





Cement pools in a commercial farm at Port Moresby. Meander design increases edge length for basking. (Photo: R. Whitaker)

Guinea the wild crocodiles belong to the people who own the crocodiles' habitat and that almost invariably means the local community. The basis of the national crocodile policy is utilization of this resource for the benefit of the rural communities and, as far as possible, by the community members themselves.

Until the mid-1960s crocodiles in Papua New Guinea were hunted virtually without restriction and since maximum pressure was applied to the bigger, financially more rewarding, crocodiles their numbers were drastically reduced. As a first step to halt the decline a law was introduced to ban the export of all skins in excess of 50.8 cm (20 in.) belly-width, which corresponds roughly to the size at which the crocodiles reach maturity. The aim of course was to protect the breeding stock. From what is known about crocodile mortality in the wild it is obvious that the greatest potential

offtake from a wild population is to be obtained from very young crocodiles or, greater still, from eggs. These are replaced rapidly whereas it takes years and involves the loss of hundreds of eggs and hatchlings to replace one big breeding crocodile. But, equally obviously, it would be an appalling economic waste to export tiny skins.

In the early 1970s a national crocodile policy was formulated by the Government of Papua New Guinea in which the aim was to harvest small crocodiles and grow them to commercial size in a network of village "farms" (more accurately, rearing pens). It was recognized that small, unsophisticated establishments would be unable to cope with problems such as drought, flooding or seasonal feed shortages so that some large, technically more-advanced rearing stations would have to be included in the system to provide an outlet for small,

live crocodiles that are surplus to the village rearing capacity but too small for skin production. The collection of small crocodiles rather than eggs was encouraged because the chances of success at the village level are greatest if a start is made with young crocodiles, preferably already past the hatchling stage. Similarly, captive breeding was not encouraged because that too requires facilities and resources not easily acquired by the majority of the village people for whom the policy was designed.

REARING CROCODILES IN CAPTIVITY: THE VILLAGE LEVEL

Crocodiles are located at night, usually from a boat, by shining a torch along the edge of rivers and lagoons. Because of a reflective tapetum the eyes of crocodiles glow reddish or orange and are visible from a hundred metres or more. At closer range it is possible to judge the size of the animal at least approximately. Dazzled by the torch beam they will tolerate a very close, stealthy approach and small crocodiles can simply be grabbed by hand, though a scoop net is more successful. They can then be transported in sacks to the rearing pens.

The minimal requirements of a village crocodile pen are an adequate body of water with provision for keeping it clean, access to land with shade and sunshine for basking, and good ventilation. Villagers are encouraged to construct pens of about 10 × 10 m using locally available, unseasoned posts or palings made from split palm and lashed together at the top with bush rope made from lianes. The least durable of the fence materials in popular use will only last for about a year but they are cheaply and easily replaced. The fence should stand about 1.25 m high and be sunk into the ground to a depth of 40 or 50 cm for rigidity and to prevent the crocodiles from burrowing underneath. A pool must be excavated to occupy about half of the pen's area and to hold water to a depth of about 60 cm. The remaining pen space is planted with tall vegetation to provide shade and some seclusion. Until vegetation is established (and this can include

Food must be in pieces which can be swallowed





Crocodiles can easily be caught with a noose around the upper jaw. A second noose can then be slid down the rope to encircle both jaws and pull them closed. (Photo: Wildlife Office, Papua New Guinea)

food plants such as banana, cassava or corn) a simple shelter should be erected to provide shade. A pen of this size will accommodate about 100 crocodiles of up to 20-cm belly-width, which corresponds to a length of almost 1 m and weight of some 2.8 kg (see table). Such a pen is also suitable for smaller numbers of bigger crocodiles but, with animals of more than 25-cm belly-width, a pen of the same design but of four times the area would be more appropriate. It is difficult, at this stage of our knowledge, to be dogmatic about stock densities since so much depends on how well the pen is managed. Juvenile crocodiles seem to be tolerant of crowding provided their pens and water are kept clean and the animals are of approximately equal size. Bigger, stronger animals can become dominant to such an extent that smaller individuals will not even attempt to feed. Therefore, because of the need for size segregation, it is necessary to have separate pens rather than larger enclosures for growing stock.

Food should be offered daily and, ideally, slightly in excess of requirements, though a day's abstinence each week will do no harm. Food is best placed on land to avoid fouling the water. Feeding boards should be kept clean by scrubbing and uneaten food should be removed after two or three hours, although, with newly-acquired, nervous animals, the food

may have to be left overnight. In the villages of Papua New Guinea the food consists almost always of locally caught fish, this constituting a good diet provided the whole fish is used. But the food must be in pieces which the crocodiles can easily swallow. Sharp bone from chopped fish should not be given to hatchlings or very young crocodiles. The diet for these should comprise very small fish supplemented by other food such as tadpoles or insects.

Food consumption is about 3-4 percent of body weight daily in hatchlings but falls off, as does growth rate, with age. Joanen and McNease (1977) recorded that food conversion (dry weight basis) was 77.1 percent during the first 2.5 months of life at 29.4°C. The same authors reported a 49.5 percent food conversion over a two-year period. In Papua New Guinea a gross food conversion ratio (growth in weight as a proportion of fresh weight of food eaten) of 25 percent is believed to be reasonable in one- to two-year-old crocodiles fed on fish. On government farms fish-fed crocodiles have increased their belly-width by 25 cm over three years. These rates can very probably be improved upon and faster growth has been reported with different species elsewhere. Growth trials have been set up to provide essential data for economic analysis, but existing, inconclusive data indicate that maxi-

mum profitability is obtained by culling at 38-cm belly-width. Hatchlings will not, therefore, reach commercial size in less than four years and crocodiles collected as juveniles with a belly-width of 10-13 cm require a rearing period of 36-40 months. During this time each will consume 120-140 kg of fish and multiply its skin value by 30. At current prices a 38-cm top-grade *porosus* skin is worth US\$ 145 in Port Moresby. However, crocodiles that have been grossly underfed for two years have shown remarkably little growth. Such underfeeding, of course, would soon have killed mammals or birds.

IMPROVED REARING TECHNIQUES AND CARE OF HATCHLINGS

With a simple rearing establishment as described above it is essential to have a good supply of water and feed available at all times. With a perennial spring or stream and a reliable source of food one can be as confident of success as in any conventional farming enterprise. In practice, however, in the villages of Papua New Guinea, water levels are subject to enormous seasonal fluctuations and the fish supply is correspondingly variable. Under these circumstances the youngest, most delicate crocodiles do not usually survive, although they are not difficult to rear in technically more-sophisticated farms where even hatchlings can be reared on a commercial scale with a mortality of less than 20 percent.

Success has been demonstrated in several parts of the world using a variety of pen designs, stock densities and staple feeds. It appears that the essential requirements are as already outlined and that very young crocodiles do not need special conditions so much as scrupulous attention to basic essentials — including hygiene.

Obvious improvements on the simple village enterprise include the provision of a freezer to buffer the farm against irregular availability of feed. This also facilitates the use of a variety of feed, such as slaughterhouse offal or trash fish, that can be bought periodically. Indeed a crocodile farm can ideally be associated with an



Skilled labourers catching crocodiles by hand



Even fairly small crocodiles can be difficult to carry

establishment producing wastes of this kind. Food preparation should be done in a fly-screened enclosure and cutting boards must be kept clean. The cutting of food for small crocodiles is laborious but mincing machines cannot be used as they reduce the food to a mush, which is unpalatable and is soon scattered throughout the pens and pools. Cutting machines that dice the food instead of mincing it would be excellent.

The use of smooth (non-abrasive) concrete for pools prevents crocodiles from burrowing into the poolside and greatly simplifies the job of keeping pools clean. In this connection each pool should have a separate water

inlet and outlet so that it can be independently drained, scrubbed and refilled. Pools can be made as meandering channels in order to increase the water edge (along which crocodiles tend to bask) for a given area of water. An S-shaped channel has proved satisfactory in pens of 20 m × 20 m, the channel being 2 m wide, spoon-shaped in section and 60 cm deep at centre. Pens of these dimensions are ideal for crocodiles of 12-to-30-cm belly-width (segregated by size) and these could be used for all stock from young juveniles to culling size, though fewer, bigger pens would cost less for the latter.

Various types of fencing have been

tried. Wire netting has the advantages of being relatively inexpensive and of permitting free ventilation. It has the disadvantage of being easy for crocodiles to climb. For mature crocodiles and animals of over 20-cm belly-width a heavy-gauge chain-link fence 1.6 m high with a 60-cm overhang on the inside, has proved entirely satisfactory. The fence is supported by galvanized steel posts and is buried to a depth of 60 cm. With smaller crocodiles the mesh size must obviously be small enough to prevent heads being pushed through, but, even then, the thin wire can cut the snouts of young animals — especially newly-caught ones trying to escape. A smooth skirting of wood or sheet metal will do much to prevent this and will discourage climbing. Entire walls of sheet metal are satisfactory except when pens are so small that the necessary height of the wall restricts ventilation and causes the air in the pens to become stagnant.

Pens for hatchlings need not be larger than 6-8 m², because hatchlings are best reared in batches of around 15 to 20 individuals for the first few months. This way they can be given more-intensive care and weak ones can be quickly identified and separated from the stronger animals. Having hatchlings in small batches also safeguards the stock, to some extent, against the spread of disease but obviously strict hygiene and a water

Measuring "belly"-width



supply independent of other pens is essential for each batch. It is important also to provide protection against predators without at the same time unnecessarily restricting ventilation. This can be done by enclosing an entire block of hatchling pens within a wire netting enclosure. If live food can be supplied this undoubtedly is a great advantage. One village in Papua New Guinea has shown remarkable success in rearing hatchlings on a diet of chopped fish and live freshwater shrimps. Regrettably the village seems to be unique in having an adequate local supply of the shrimps.

Accepting that natural food may not be available it is wise to use entire fish, including entrails and ground bone, and to supplement this with other chopped meats to avoid dietary deficiencies. There is much scope for research in this field. The addition of vitamin and mineral preparations for example, is likely to be beneficial. One authority has recommended the addition of a teaspoonful of cod-liver oil to each 450 g (1 lb) of chopped meat three times a week (Pooley, 1971).

It is not uncommon for very young crocodiles, when newly captured, to refuse to eat in captivity. In such cases, after a few days, it is advisable to force-feed by opening the jaws and gently pushing food (preferably a small fish or tadpole) into the throat with a smooth rod. The jaws should

then be held closed and the throat massaged to induce swallowing. This will maintain the animal's condition until, as usually happens, it begins eventually to feed with the others.

EGG COLLECTION, INCUBATION AND CAPTIVE BREEDING

Egg collection. If eggs to be collected from the wild are thought to be in danger of destruction by flooding or predation then obviously the sooner they are collected the better. But certain rules must be observed as the delicate blood vessels of early embryos are very easily torn by movement of the egg, and embryos generally are vulnerable to sudden temperature change. If eggs can be collected within one or two days of being laid then all should be well but if not they should be left until at least

the fifth week of incubation, and preferably until the end.

Eggs should not be collected at a time of day when the air temperature is extreme and the opened nest should be shaded from the sun. It is essential to handle eggs extremely carefully (as one writer has put it, as if they were loaded with high explosive). As each egg is uncovered it must be marked on the upper surface with a felt-tipped pen and placed in the same position in the transport box.

For short, smooth journeys, or air travel, a stout cardboard box is suitable for transport. The eggs can be firmly packed in slightly damp leaf-litter or, if from a mound nest, the actual nest material. For bumpy journeys by road a wooden box with a hinged or screwed lid is better and slightly damp sand should be used for

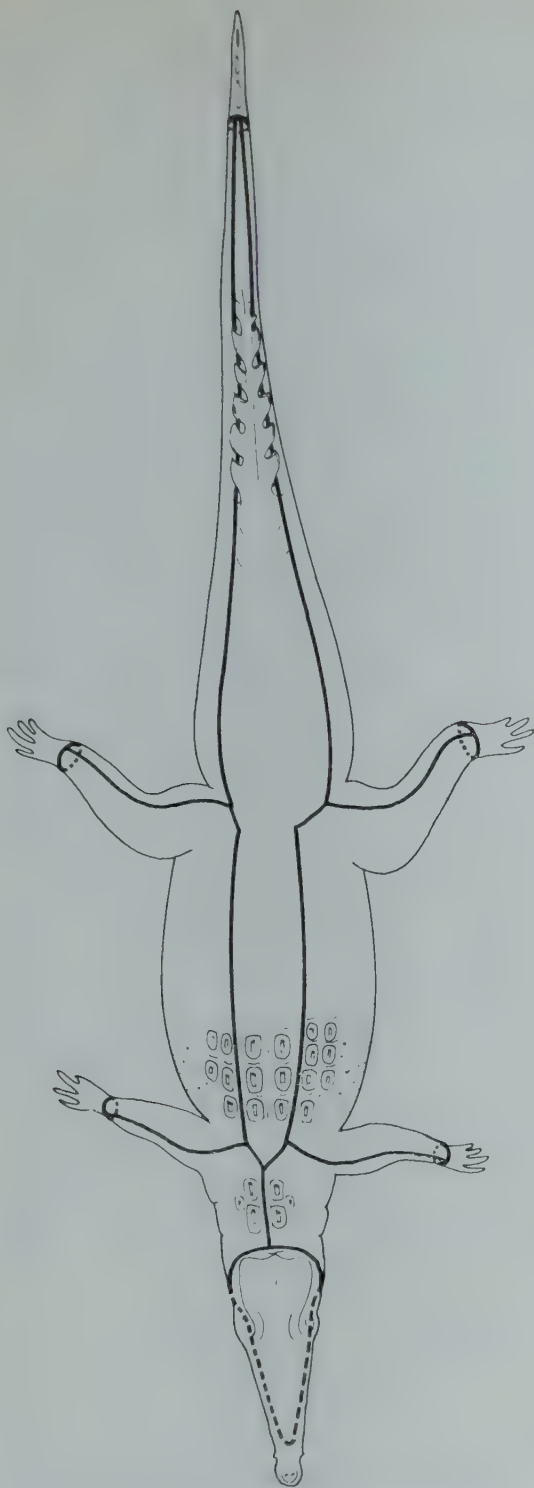
Relationship between "belly"-width and length/weight in pen-reared crocodiles										
"Belly"-width to nearest cm (inches)	8 (3)	10 (4)	15 (6)	20 (8)	25 (10)	30 (12)	36 (14)	41 (16)	46 (18)	51 (20)
Total length to 0.5 cm	46	56	79	97	113	129	144.5	157	172.5	185
Snout-vent length to 0.5 cm ¹	23	28	38.5	47.5	56.5	65.5	73.5	81.5	85.5	92
Weight in kg	0.27	0.61	1.35	2.8	5.25	8.75	13.5	19.5	26	31

NOTE: There is much individual variation and captive animals may become much fatter than wild ones. These values are means from a total of 636 mixed *C. novaeguineae* and *C. porosus*.
¹ From tip of snout to anterior extremity of cloaca.

Skin of salt river (*C. porosus*) crocodile — 45 cm belly-width



packing. This must completely fill the box to prevent any shifting. A box with internal dimensions of about 54 × 34 × 34 cm is of a convenient size. It will accommodate 40 eggs in two layers of 20 with 6 to 8 cm of sand above, below and between the layers. Each layer is made up of four rows of five eggs placed a finger-width apart with a margin of 6 cm between the eggs and the sides of the box. Such a box will be heavy to transport but will protect the eggs very well and, with the refinement of aeration holes, can be used as an incubation box so that the eggs need not be further disturbed until hatching time.



Skinning cuts from dorsal surface

This skinner begins at the forelimb. Note the initial skinning cuts. (Photo: Wildlife Office, Papua New Guinea)



Incubation. Various techniques have been described in the literature. Experimentally, Joanen and McNease (1977) obtained a 94-percent hatching success by setting eggs on trays in environmental chambers with a temperature range of 28.6-33.3°C and a relative humidity of around 92 percent. On a larger scale Pooley (1971) has described a hatchery in which artificial nests were excavated in sand over a porous substrate within a large wire enclosure. Whitaker and Whitaker (1977) have been successful using wooden transportation/incubation boxes as described above. Other workers have built artificial mound nests as appropriate to the species. The essentials are to maintain a steady incubation temperature of between 28°C and 34°C with a high humidity and no disturbance. In practice humidity can be judged adequately and maintained by sprinkling water as necessary. Sand should be just moist enough to retain a shape when squeezed. Obviously the hatchery must be enclosed against predators. Under these conditions hatching may be expected after 80 to 90 days. At this time the squeaks of crocodiles ready to hatch will be audible and may be produced in response to tapping the incubation box or brushing the sand from the nest. Pooley (1971) reports that playing tape recordings of hatching calls is an excellent stimulus to hatching.

The young should be allowed to

escape from the egg unaided, a process which may take many hours. Any young which are still in difficulty after 24 hours should be helped but eggs should not be broken open until a week after the first egg of a clutch has hatched and been seen to be normal. Premature crocodiles will have bellies distended with unabsorbed yolk. They should be kept in a clean glass tank on damp cloth in a darkened room until the yolk has been absorbed and the "umbilical" scar has healed. They must be protected from ants and flies.

Captive breeding. Both species of crocodile in Papua New Guinea are being successfully bred on a government research farm near Port Moresby, but as captive breeding is not central to government policy there has been no attempt to expand or commercialize this research. A breeding ratio of one male to five females has had limited success with a total of 30 *C. novaeguineae* in a breeding enclosure of 60 m × 55 m containing an earth pool of 40 m × 30 m. Mating takes place in the water, which need not be more than 1.5 m deep. Females have been allowed to select a nest site and complete their parental behaviour but eggs have also been taken up and artificially incubated.

Because of territorial behaviour it will probably prove more satisfactory to keep breeding pairs or trios in separate enclosures although apparently territorial fighting can be overcome to some extent by keeping so many together that normal territorial behaviour becomes difficult or impossible to maintain. Yangprapakorn, McNeely and Cronin (1971) have described how more than 200 adult crocodiles, at a sex ratio of one male to three females, are managed in a concrete pool of 0.2 ha with a land area somewhat larger than the area of the pool. In Mr Yangprapakorn's enviably successful crocodile farm near Bangkok the breeding females are supplied with nesting material in brick-built stalls of 4 m × 4 m with a small doorway and no roof. Each female selects her stall about a week before laying and after laying the mother is chased out of the stall and the door is closed for the entire

incubation period. The eggs are left to incubate naturally, but there may be some adjustment of nest material and sprinkling of water to maintain the correct temperature and humidity. The nest is inspected very frequently as hatching time approaches and the hatchlings are taken at once to be reared in small hatchling pens.

There is no doubt that, within the tropics at least, crocodiles can be bred in captivity on a commercial basis, but the economics of the business will depend very largely on local labour and feed costs. Crocodiles of 3-m length may weigh 150 kg or more and a 4-m crocodile can be double that weight. Even if such animals eat only 1 percent of their body weight in fish each day the annual feeding cost for a breeding stock could obviously be considerable. It is possible, however, that a much lower food intake would be adequate for adult crocodiles.

KILLING, SKINNING AND SKIN PREPARATION

In Papua New Guinea the "belly"-width is actually measured between two specific points in the thoracic region. On the animal's back are raised horny scutes which form rows both transversely and longitudinally. The tape is aligned with the third transverse row (from the anterior) and the measurement is taken between the outermost edges of the outermost scutes.

Crocodiles can be safely caught with a noose on a pole but skilled labourers find it less troublesome to wade into the ponds and catch them by hand! The jaws are tied and the crocodile is killed by flexing the neck over a small log and forcing the point of a knife into the back of the head immediately behind the bony platform. If done properly with a single jab, it kills the animal instantly by severing the spinal cord between the skull and first cervical vertebra.

The animal is then left in the shade (an hour's hot sun will ruin the skin) until bleeding and movements have ceased. It is then hosed down and skinned. A full commercial skin is obtained by flaying from a series of



Government buying scheme enables villagers to sell young crocodiles at controlled prices for transfer to commercial farms.

cuts as shown in the figure. Dorsal skin, head, feet and tail tip are of no value to the tannery. Skinning must be expertly done as perforations in the skin can halve the value. Skins will also be downgraded for serious blemishes such as old wound scars or poor preservation.

Preservation is of crucial importance. First the skin must be thoroughly scraped with a shell or a blunt blade to remove all connective tissue, fat and muscle. Salt must then be applied liberally to the raw surface and rubbed in well.

The skin should then be rolled and stored on a rack in a secure, shaded place to drain for a day. The salt will draw a great deal of water from the skin and this must be allowed to drain away. The skin may then be unrolled and the salt shaken off (it can be dried and used again for the same purpose). Clean, unused salt must now be rubbed into the skin and this must be mixed with an additional preservative since salt alone will not prevent putrefaction for long periods in tropical conditions. The skin should then be rerolled, after folding-in the leg and side sections. It is then ready for despatch to a tannery.

Proprietary skin preservatives can be obtained from chemical suppliers but a small-scale test showed that the

addition of only 1.1 percent borax and 1.1 percent naphthalene, measured by weight and *thoroughly* mixed with the salt, could keep crocodile skins in a condition completely acceptable to a leading tannery for up to 6 months at a storage temperature of around 30°C. Control samples treated with salt alone became putrid.

In Papua New Guinea little attempt has yet been made to market the by-products of crocodile skin production. The flesh of slaughtered crocodiles can be fed to the stock but the tail produces steaks that are wholesome and palatable and sought after by Western tourists keen to try exotic dishes. The gall bladder, male genitalia and even strips of dried flesh sell readily in the East where they are believed to have medicinal properties. Crocodiles that die prematurely can be prepared as curios by taxidermists and in Bangkok the heads, feet and teeth of bigger animals are also sold as curios.

It is clear that a great deal can be done to develop crocodiles as an economic resource and it need not involve the extermination of wild populations. Indeed it would be tragic if this precious resource continued to be wantonly destroyed. ■

References

- BLAKE, D.K. & LOVERIDGE, J.P. 1975. The role of commercial crocodile farming in crocodile conservation. *Biological Conservation*, 8: 261-272.
- JOANEN, T. & MCNEASE, L. 1977. Artificial incubation of alligator eggs and post hatching culture in controlled environmental chambers. 8th annual World Mariculture Society meeting, San José, Costa Rica.
- POOLEY, A.C. 1971. Crocodile rearing and restocking. In *Crocodiles*. IUCN Publications New Series, Supplementary paper No. 32, p. 104-130.
- WHITAKER, R. & WHITAKER, Z. 1977. Collection and hatching of marsh crocodile (*C. palustris*) eggs. *J. Bombay nat. Hist. Soc.* 73(2): 403-407.
- YANGPRAPAKORN, U., MCNEELY, J.A. & CRONIN, E.W. 1971. Captive breeding of crocodiles in Thailand. In *Crocodiles*. IUCN Publications New Series, Supplementary paper No. 32, p. 98-101.

Environment. The nine States of northeastern Brazil form a natural region separated by climate and vegetation from the rest of the country. The States are: Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia (see figure). Although their combined area is 1 548 672 square kilometres, 18.2 percent of the area of the whole country — their population, 28 million in 1970, is 30.2 percent of the total population.

In this region there are three climatic/vegetation zones:

- A wet zone that covers the state of Maranhão and a narrow strip round the coasts of the other states. It is called in Portuguese the *Mata*, which implies that it used to be forest;
- The Agreste, a slightly wider transitional zone inside the *Mata* along the west coast;
- The Sertão or dry inland region.

The drought polygon is essentially the Sertão. It covers all the nine states except Maranhão, the coastal areas of the other states, and part of inland Bahia. It also includes part of Minas Gerais. Its total area is 937 000 km². Rainfall is low and irregular; it averages 300-800 mm per annum falling in 4-6 months. Temperatures are high (mean annual temperatures vary between 22° and 28°C) and evaporation may be as high as 66 percent of precipitation. Droughts are common — there have been six major droughts in this century.

Most of this area is a low plateau between 200 and 800 m in altitude with lower ground in the river valleys

I.L. Mason

Sheep and goat production in the drought polygon of northeast Brazil



The author can be contacted c/o Animal Production and Health Division, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy. This article is based on his experience during an EMBRAPA/IICA consultancy on goat and sheep breeding in northeast Brazil.

and a few scattered areas of hills or low mountains — presumably remains of an ancient eroded peneplain. Water is held in temporary ponds and in dams. The soil is thin and poor.

The typical vegetation of the Sertão is called *caatinga*. This is a secondary cover following centuries of felling and over-grazing. It consists of a mixture of small trees and bushes with some herbaceous ground cover. The principal components are species of *Mi-*

TABLE 1. Livestock numbers in northeastern Brazil

Animal	Year of census	Number of animals Thousands	Number of farms Thousands	Average number of animals per farm	Percent of total in Brazil
Cattle	1975	17 890	770	23	17.7
Pigs	1975	9 463	1 036	9	26.9
Goats	1975	6 095	411	15	92.3
Sheep	1975	5 290	299	18	30.6
Horses	1974	1 469	—	—	28.2
Donkeys	1974	1 448	—	—	92.3

Source: Brazil, 1977.



Santa Inês sheep at Iguaraçá State Breeding Farm, Pernambuco, Brazil



Santa Inês sheep with tan spots on head (the sheep called Cara Negra) on farm of José Ramos, near Vava, Bahia, Brazil

mosa, *Prosopis*, *Caesalpinia*, *Cassia*, *Bauhinia*, *Jatropha*, *Cordia*, *Zizyphus* and *Spondias*. In the moister areas they form an almost impenetrable thicket; in the drier areas the bushes are spaced out and cactuses are common. The ground cover is formed of various grasses, legumes and bromeliads. The tallest trees are the carnaúba palms in the wetter areas.

In some places the *caatinga* has been cleared for grazing. In others cotton has been planted. Apart from this, and small patches of subsistence crops (maize, pulses, manioc, vegetables, fruit), there is little cultivation outside the areas of irrigation.

Livestock. The livestock population of the nine northeastern states is

TABLE 2. Sheep and goat populations of the northeastern states, 1975

State	Area km ²	Sheep '000	Density per km ²	Goats '000	Density per km ²
Maranhão	328 663	120	0.4	304	0.9
Piauí	250 394	789	3.1	1 309	5.2
Ceará	150 630	1 066	7.1	649	4.3
Rio Grande do Norte	53 015	272	5.1	158	3.0
Paraíba	56 372	360	6.4	365	6.5
Pernambuco	98 281	477	4.9	1 011	10.3
Alagoas	27 731	128	4.6	66	2.4
Sergipe	21 994	109	5.0	15	0.7
Bahia	561 026	1 970	3.5	2 216	4.0
Northeast, total	1 548 672	5 290	3.4	6 045	3.9
Northeast, excluding Maranhão	1 220 009	5 170	4.2	5 791	4.7

Source: Brazil, 1977.

shown in Table 1. The overwhelming importance of the northeast in goat and donkey production is clear. If figures were available for hair sheep it would also be clear that over 90 percent of the hair sheep are in this region. (The majority of wool sheep — 11 million — are in Rio Grande do Sul.)

Cattle are found most frequently in areas with over 500 mm of rain annually. They are chiefly zebus or zebu crosses for beef production.

with over a million sheep has the highest density of any state in the northeast. Density is also above average in Paraíba for both sheep and goats. There are few of either species in Maranhão.

Sheep breeds. The average flock of sheep in the northeast exhibits a multitude of types. Some are hair sheep (woolless); some have a small amount of wool that sheds; some have a light fleece of coarse wool.

have been the Churro which came first. These early imports gave rise to the coarse-woolled, horned Crioulo breed which is still common, just as the Criollo derived from the Spanish Churro is the dominant breed in the upland areas of Spanish America. (It is the dominant breed in Bolivia, Ecuador, Guatemala, Mexico and Peru.) During the period of the importation of slaves from West and Central Africa (seventeenth and eighteenth centuries) sheep were also



Local mixed sheep near Sobral, Ceará, Brazil

Very few of the original Northeastern Crioulo (or Curraleiro) remain. The horses are small and are used for riding or draught. They are called "Northeastern". Small grey donkeys are ubiquitous; they are used for pack or riding. Fat little black pigs (occasionally red or pied) scavenge individually, particularly in villages. Goats are found everywhere but especially in the regions with less than 500 mm of rain where no other agricultural activity is possible.

Bahia is the largest state and has the greatest number of small ruminants with 2 million sheep and 2.2 million goats (see Table 2). Piauí and Pernambuco each have over a million goats and a density higher than the average for the region. Ceará

Most are polled but sometimes males, and more rarely females, carry light horns. The commonest colours are tan (red-brown) and white but some sheep are tan-and-white and black-pied animals also occur. Ears are commonly horizontal but lop ears are frequent. Traces of fat tail are seen in some districts.

A tentative explanation of the origin of this mixture is as follows. The first sheep imported were probably from Portugal in the sixteenth century. Domingues (1954) asserts that the breed imported was the Bordaleiro which is similar to the Entrefino breeds of Spain, i.e., intermediate between Merino (fine-woolled) and Churro (coarse-woolled). In the author's view, it may equally well

imported to Barbados, Brazil, Colombia and Cuba. These were hair sheep with no trace of wool. Females were apparently polled but males were sometimes horned. They flourished in the tropical areas and were able to penetrate into hot humid areas unsuitable for woolled sheep. However, this constraint on woolled sheep does not exist in northeast Brazil so the present population shows clear evidence of a crossbred origin.

In this century there have been two additions to this already mixed population. The Bergamasca breed arrived from Italy in the late 1940s. It is a tall, white, hornless, lop-eared, Roman-nosed, coarse-woolled breed from the Alps. It must have come via the south of Brazil since its

crossbreeds are known by the names Santa Inês (a town near Salvador in Bahia) or Pelo de Boi Branca de Bahia. (Bahia is the most southerly of the northeastern states.) A new breed is now being developed under the name Santa Inês which has a Roman nose, lop ears, and is taller than the local sheep. Its colour may be white, tan, black or pied.

From the West Indies have come descendants of the Blackhead Persian, which is a derivative of the fat-rumped Blackhead Somali. The Brazilian Somali has lost all but a trace of the fat rump — it is reduced to a thickening at the base of the tail — but the black head, a result of a single dominant gene, remains. Crossing with the Crioulo has introduced a certain amount of wool into the original hair coat, and occasionally horns. This breed is much less common than the others.

The pure hair types from the local sheep are now being selected to form a new breed under the name Morada Nova. Animals with horns, wool or lop ears are rigidly culled since they indicate admixture of Bergamasca or other woolled breed. Colour is arbitrarily restricted to white or tan. The resulting breed is similar to the African sheep of Colombia and the Pelibuey of Cuba and Mexico but the males lack the throat ruff or mane that is so characteristic of these breeds as it is of the Barbados Black Belly and the small hair-sheep of coastal West Africa.

There is so far no initiative to reconstitute the woolled Crioulo breed by selection from the present mixture.

Goat breeds. At first sight the goat population appears extremely heterogeneous because of the variety of colours and patterns. On closer examination it reveals itself as remarkably uniform in general type and conformation. Most animals are small and compact with erect or horizontal ears, short, curved horns in the female and longer, twisted horns in the male, and short, sleek coats. Sometimes the coat is longer, especially on the hind-quarters, and sometimes the ears droop. This goat population is called SRD (Sem Raça Definida) and it ap-



Local mixed sheep with Santa Inês ram near Sobral, Ceará, Brazil



Local SRD goats on Castelo di Piauí research farm near Teresina, Piauí, Brazil

pears to show no regional variation over the whole northeast.

Attempts have been made to pick out groups of animals of specific colours and call them breeds. These are defined as follows: Moxotó — white or buff with black back- and face-stripe and black belly; Repartida — black forequarters and paler hind-quarters, also with black back-stripe; Marota — white; Canindé — black with pale face-stripe and belly.

Although the Moxotó pattern appears to be more numerous in the valley of that name than elsewhere, and one flock has been bred at a govern-

ment farm in Pernambuco state since at least 1945, there is no evidence that it differs in size, performance or morphology from the generality of prick-eared goats of the northeast. The evidence for breed status for the other colour types is even more tenuous.

One would expect that the first goats came from Portugal. The Charnequeiro has been suggested as the original but there is little trace of its convex profile and long, spiral horns in the present population. Later imports may have come from other parts of Europe and they would all have been short-eared and mostly short-

haired (there is no trace of the dwarf West African type seen in the West Indies).

Whatever the origin, centuries of natural selection have produced a remarkably uniform and adapted type. The diversity of colour indicates that colour has no natural selective advantage, nor has it been selected artificially by man. More recently, various oriental lop-eared breeds have been imported; crossing these on to the Crioulo type has introduced the lop ears and created the present SRD population. The chief among these are the Anglo-Nubian (which has also introduced polledness) and the Bhuj, a breed which came via the island of Fernando de Noronha. It has the black colour and white or spotted ears of the Gujarat breed of India and must originally have come from Bhuj in Kutch, Gujarat, probably at the same time as the Gujarat (Kankrej) and Gir zebus (1875-1964).

Sheep and goat husbandry. In the completely traditional system of management sheep and goats are run together in the unimproved *caatinga*. There is no perimeter fence to the farm so neighbouring flocks may mingle. The animals pasture entirely off native bush and no supplements are given. In the dry season the animals must feed entirely on the trees and bushes, and particularly on fallen leaves and fruits (e.g., *umbu*, *Spondias purpurea*). They may come

TABLE 3. Frequencies of improved husbandry practices in northeast Bahia, 1974

Husbandry practice	Percentage of farms
Use of males of recognized breeds	16
Internal fencing	0
Improvement of <i>caatinga</i> by cutting	0
Peripheral fences	77
Corrals	94
Covered area in corrals	40
Water available	93
Water available all year round	44
Castration	100
Deworming and vaccination	18
Mineral supplement (NaCl)	36
Recording of births	3
Weight recording	1

back to the neighbourhood of the homestead at night, especially if this is the only watering point. Usually there is a fenced corral in which they spend the night. There is no veterinary attention and no special care for mothers and newborn. Breeding is at random throughout the year; castration is sometimes practised but not before six months of age. Weaning occurs naturally.

The first management improvement to be introduced has been provision of perimeter fences to the farm. Oc-

casionally there are also internal fences dividing the bush into paddocks. The corrals may be provided with roofed areas. Mineral supplements are given, but only in the form of common salt. Deworming may be done sporadically.

On improved farms special pastures may be planted with grass or spineless *Opuntia* as a reserve for use in the dry season. Cattle graze first, then sheep and goats. All farms have fenced corrals and dams for dry season water supply. External parasites and worms are treated but not always systematically. Castration is still sporadic and mating is free throughout the year, but males of improved breeds may be used.

A survey (Bahia, 1975) made in 1974 of 80 farms in northeast Bahia, a dry area where most of the sheep and goats of the state are found, indicated the frequencies of various improved husbandry practices shown in Table 3.

Diseases. The most serious diseases are gastrointestinal helminths, caseous lymphadenitis, contagious eczema and foot-and-mouth disease. In the Bahia survey it was estimated that each of these diseases separately was affecting nearly one-quarter of the animals surveyed. Mortality is high — total deaths per year amounted to 35 percent for goats and 42 percent for sheep. In addition to disease, animals are lost through predators — dogs and the carrion hawk, *Milvago chimachina*.

Performance. In the Bahia survey, age at first mating was 12.4 months for goats and 12.2 for sheep. Litter size was 1.4 and 1.3 respectively but fertility was low so that the number of young per adult female was only 1.1. Only 64 percent of goats and 62 percent of sheep born survived to weaning. Slaughter age averaged 15 months at a weight of 20 kg. Much of this meat is used by the family and farm workers; the rest is sold, usually through intermediaries.

Similar figures for performance are given for Ceará state (Empresa Brasileira de Pesquisa Agropecuária, 1975) except that, with improved management, adult mortality is stated to be 10-15 percent. Again for Ceará (Ceará,

Bhuj goats (females) at Castelo di Piauí research farm near Teresina, Piauí, Brazil — note stone slab fences



1975) animals are slaughtered at 12-14 months and carcass weight of 10-15 kg; on better farms (with control of worms) this figure goes up to 15-20 kg.

What little wool is present is not shorn but is allowed to shed. Sheep are not milked. Some goats are milked for household use but there is little commercial production of milk.

Skins are the most important commercial product of the northeastern sheep and goats.

Research, extension and development. For many years the northeast was the poor relation in Brazil. Its agriculture was neglected — and especially its sheep and goats. In the last few years development agencies

instance: What is the best breeding season? What are the best ages for castration (if it is necessary) and weaning? Do the “improved” breeds give a better economic return than the local adapted ones? What is the best supplementary feed to give in the dry season and in what form should it be fed? What is the palatability and feed value of the various constituents of the flora of the *caatinga*? What is the best deworming routine to employ? What are the correct treatments for caseous lymphadenitis and contagious eczema?

There was an FAO livestock project in the northeast, based on Recife, during the years 1972-76 but it achieved little (and nothing on small ruminants) because the research organizations

buildings for offices, laboratories and administration are being constructed on the experimental farm (of 1 200 ha) 8 kilometres away. They should be ready for occupation in late 1979. The present staff consists of a director and 15 research workers. Current research covers the fields of nutrition, pastures, management, parasitology, reproduction, breeding and climatology. It is actively seeking answers to the questions listed above.

In addition to the work at the Centre in Sobral, Centro Nacional de Pesquisa de Caprinos (CNPC) cooperates with state, university and other research organizations in the northeast (e.g., EMBRAPA Centro de Pesquisa Agropecuária do Trópico Semi-árido, Petrolina, Pernambuco). ■



Marota goats on farm of José Ramos near Vava, Bahia, Brazil



Moxotó goat (female) at Iguaraçá State Breeding Farm, Pernambuco, Brazil

such as SUDENE (Superintendência do Desenvolvimento do Nordeste), BNB (Banco do Nordeste do Brasil) and DNOCS (Departamento Nacional de Obras Contra as Secas) have been pouring money into agricultural development projects — including some that involve sheep and goats.

The need to advise farmers on the best measures to improve their flocks and herds has led to the setting up of the extension agency EMATER which is the regional organ of EMBRATER (Empresa Brasileira de Assistência Técnica e Extensão Rural). Its activities are hampered by the lack of research information on tropical goats and sheep in Brazil. Answers to the simplest questions are lacking; for

were being reorganized. (Its pasture component has continued and is now based on Teresina, Piauí). This reorganization of agricultural research culminated in the formation of EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). It has established national centres devoted to specific crops or livestock species and also coordinates state activities.

The National Goat and Tropical Sheep Research Centre (Centro Nacional de Pesquisa de Caprinos e Ovinos Deslanados) started functioning in January 1977. It is situated at Sobral-Ceará, a few degrees south of the equator at an altitude of 75 metres. At present it is housed in temporary buildings in the town but permanent

References

- BAHIA. SECRETARIA DA AGRICULTURA. 1975. *Aspectos de produção de caprinos e ovinos no Nordeste da Bahia*. Salvador, Bahia, Serviço de Economia Rural.
- BRAZIL. SECRETARIA DO PLANEJAMENTO. 1977. *Anuário Estatístico do Brasil*. Rio de Janeiro, Fundação Instituto Brasileiro de Geografia e Estatística.
- CEARÁ. MINISTÉRIO DE AGRICULTURA. 1975. *Ovino caprinocultura plans de desenvolvimento*. Ceará.
- DOMINIGUES, O. 1954. *Sobre a origem do carneiro deslando do Nordeste*. Fortaleza, Seção de Fomento Agrícola no Ceará. Publication No. 3.
- EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. 1975. *Sistemas de produção para caprinos e ovinos*. Quixadá, Ceará. Circular No. 70.

Beekeeping in Tunisia

its impact
on other developing countries
of the Mediterranean basin

A. Popa

Beekeeping is one of the oldest forms of agriculture. It developed with the evolution of human society, and in response to its needs. People have always been large consumers of honey, a food endowed with remarkable nutritive qualities, and extensive users of beeswax.

For this reason, of all the invertebrates, the honeybee has been the subject of the greatest number of studies and these have centred especially on brood rearing and beekeeping.

Beekeeping is practised today in almost all the regions of the world, but the 50 million or so existing colonies of bees are insufficient to utilize effectively the immense natural resources of nectar available in the world.

World production of honey is estimated at about 800 000 tons a year, 80 percent of which is destined for local consumption, the rest entering world trade channels. Some 90 percent of the honey marketed is table honey, the rest being absorbed by the food industry.

The degree of development of apiculture varies greatly from one region to another according to local agro-climatic conditions and the importance accorded by the authorities concerned to the training of beekeepers and spe-

FAO/UNDP projects are to be found in most developing countries of the world and concerned with almost every aspect of agriculture production. One of the most successful of these projects has been FAO/UNDP project TUN/75/005 — Assistance to the Development of Apiculture in Tunisia. This article by the FAO Chief Technical Adviser to the project describes how such a project can assist not only in the development of a national industry and in increasing the incomes of small farmers, but how assistance can be extended from it to other countries of the Region (in this case the Mediterranean Basin) and the development of the industry in those countries also.

cialists capable of introducing and promoting new technologies likely to increase honey production.

More than half the quantity of honey exported in recent years has been produced by three developing countries: Argentina, China and Mexico. This would seem to indicate that the honey-producing potential of developing countries is considerable.

During recent years a new trend has been observed in human feeding patterns revealing an increasing preference for natural, unpolluted products, among which honey holds an important place. This highly nutritious food with remarkable dietetic and therapeutic properties, rich in assimilable carbohydrates, proteins, essential mineral salts, and enzymes, is increasingly in demand and is moving away from the category of luxury product and into the daily diet.

As for beeswax, in addition to its final use, it is in increasing demand for intermediate use by modern apiculture, the electronics industry and by the pharmaceutical industry (particularly for cosmetics).

It is for these reasons that world demand for honey and beeswax greatly

exceeds supply. The main honey-importing countries are generally the industrialized and the oil-producing countries, such as Algeria, the Federal Republic of Germany, Iran, Italy, Japan, the Netherlands, Sweden, Switzerland, as well as the United States. Formerly these were honey exporters. This situation should be encouraging to a number of developing countries in North and East Africa, the Near East, Asia and Central and South America, which have an exceptional, but at present little-exploited, honey-producing potential.

Tables 1, 2 and 3 show the production, exportation and importation of honey by region, from which it appears that Asia is the largest producer, South America the largest exporter and Europe the largest importer.

Beekeeping is an agricultural activity that is particularly suited to developing countries, because it can yield excellent returns and does not require large investments of capital. Furthermore, bees procure their food themselves at no cost and at the same time help to increase agricultural production by pollinating plants. More than 80 percent of agricultural plants

DR POPA is Chief Technical Adviser (Apiculture and Pathology), TUN/75/005 — Assistance to the Development of Apiculture in Tunisia, c/o UNDP, BP 863, Tunis, Tunisia.

are in fact entomophilous and bees are among the most active pollinating insects. It has been estimated, in fact, that the indirect contribution that beekeeping makes to agricultural production is 10-15 times greater than its direct contribution. Bees adapt well to a variety of climatic conditions and produce honey even during drought years when there may be a shortfall in production in other agricultural sectors. They can thus play a compensatory role in agriculture.

Beekeeping requires a large labour force. This is also the case in its allied industries, such as the manufacture of hives and beekeeping equipment, and the extraction, processing and distribution of honey, beeswax, royal jelly, venom, etc.

In rural areas beekeeping can play an important social and economic role. It contributes towards raising the standards of living through the addition of honey to the family diet and through the additional income generated from the sale of honey, beeswax and swarms. It also helps the small farmer to settle on his piece of land thus contributing toward the reduction of the present movement out of the rural areas.

Tunisian experience. Tunisia has important nectar-bearing trees and crops such as citrus fruits, eucalyptus, rosemary, thyme, lucerne, clover,

TABLE 1. World production of honey, by region, 1971-1975
Tons

Region	1971	1972	1973	1974	1975
Africa	24 724	26 800	71 584	78 690	80 926
North and Central America	158 341	173 981	183 702	159 908	169 653
South America	37 037	37 760	37 479	43 166	40 028
Asia ¹	241 289	233 429	241 815	249 538	255 529
Europe ¹	122 427	109 797	119 393	116 422	119 490
Oceania	24 878	25 987	23 478	26 505	35 434
USSR	220 000	183 795	220 775	199 000	190 000
World total	828 696	791 549	898 226	873 229	891 060

Source: FAO. Production yearbook, 1972-1975. Rome, Italy.

¹ Not including the USSR.

almond trees, apricot trees, sunflowers and forest undergrowth, as well as a climate particularly favourable to beekeeping.

However, up to 1975, the number of colonies of bees was limited to some 6 000 colonies in modern hives and about 60 000 colonies in traditional hives. These produced about 250 tons of honey a year, covering only 25 percent of domestic consumption.

Among the main reasons for the underdevelopment of beekeeping were the insufficient number of colonies of honeybees, the archaic methods of management and reproduction, the lack of specialized staff and, above all, the absence of a national beekeeping centre to direct the development

of beekeeping at the national level.

Tunisia, anxious to remedy this situation and to develop beekeeping, approached UNDP and FAO in 1975 in order to develop a project aiming at ensuring self-sufficiency in honey production and the conversion of Tunisia into an exporting country by the end of 1981.

It is estimated that by the end of 1981 the country's honey-producing potential will make it possible to rear between 25 000 and 30 000 colonies of bees in modern hives and 100 000 colonies in traditional hives, with an annual production of about 1 000 tons of honey.

By implementing the results of scientific research and by promoting

TABLE 2. World honey exports, by region, 1971-1975
Tons

Region	1971		1972		1973		1974		1975	
	Total	% of production exported	Total	% of production exported	Total	% of production exported	Total	% of production exported	Total	% of production exported
Africa	456	1.8	927	3.5	923	1.3	345	0.4	256	0.3
North and Central America	40 427	25.5	46 830	26.9	49 349	26.9	35 655	22.3	47 614	28.1
South America	15 169	41.0	21 065	55.8	21 809	58.2	17 845	41.3	24 751	61.8
Asia ¹	30 811	12.8	35 600	15.3	27 851	11.5	20 377	8.2	27 290	10.7
Europe ¹	28 510	23.3	37 075	33.8	28 447	25.9	26 119	22.4	28 998	24.3
Oceania	11 764	47.3	10 591	40.8	9 725	41.4	5 750	21.7	10 196	28.8
USSR	4 900	2.2	3 600	2.0	5 300	2.4	7 385	3.7	6 919	3.6
World total	132 037	15.9	155 688	19.7	143 404	16.0	113 476	13.0	146 025	16.4

Source: FAO. Trade yearbook, 1975. Rome, Italy; and Table 1.

¹ Not including the USSR.

TABLE 3. World honey imports, by region, 1971-1975
Tons

Region	1971	1972	1973	1974	1975
Africa	2 782	3 758	4 926	3 813	2 872
North and Central America	5 578	18 320	5 808	11 928	22 167
South America	433	287	158	236	237
Asia ¹	18 366	25 490	27 287	16 879	19 659
Europe ¹	103 312	105 418	98 197	80 843	102 603
Oceania	125	147	130	137	139
USSR	—	—	—	—	—
World total ¹	130 596	153 420	136 506	113 836	147 677

Source: FAO. Trade yearbook, 1975. Rome, Italy.

¹ Not including the USSR.

beekeeping training at all levels, it is hoped that it will be possible to produce a surplus of honey for export.

The Project has concentrated its activities on production, research, training, extension work and technical assistance to beekeepers and farmers.

Initially two centres were set up, the first for the rearing of queens and the production of swarms and honey, and the second specializing in beekeeping technology and the production of hives and other beekeeping equipment.

The Project also has two pilot stations for the production of swarms and honey, as well as for training and extension work. These were established in the richest honey-yield-

ing regions of the country (Cap Bon and Bizerte).

The number of colonies of honeybees owned by the Project has increased 20 times since it commenced operations. It now has more than 2 500 colonies producing annually 1 000 to 1 500 swarms, 2 000 to 5 000 bred and selected queens and 15 to 25 tons of honey. In addition, within the framework of the Project, hundreds of beekeepers, technicians and engineers every year undergo basic and advanced training courses. Over 500 beekeepers, farmers and students of the Higher Institutes of Agriculture and Veterinary Medicine also participate in the demonstrations and information days at the Project stations.

Traditional beehives in south and central Tunisia



The Technology Centre, which has a section for the study of prototypes of beekeeping tools and materials, is annually producing over 2 000 modern hives plus accessories, over 1 000 metal bases, over 300 smokers and several other items such as queen-breeding units, hive tools and stamped wax. The production capacity of the Centre could be increased in order to meet the country's need for beekeeping tools and equipment.

At present the total production of hives, and over 60 percent of the beekeeping tools and equipment, are manufactured locally. By the end of the Project period it is planned to produce locally over 90 percent of the beekeeping tools and equipment needed by Tunisia.

For production and extension work, three more pilot centres are to be set up, two of which would be located at the Centre and one in the south of the country.

At the national level, the number of colonies of bees in modern hives has increased by more than 300 percent and by more than 33 percent in traditional hives. By 1977/78, the production of honey had increased to 500 tons. It is estimated that honey production in 1979 will exceed 600 tons, in spite of poor agro-climatic conditions and the appearance of a devastating parasitic disease ("Varroase"), caused by *Varroa jacobsoni* — an acarine pest of bee larvae and nymphs. The Project is now concentrating on the study of this pest.

The main requisite for ensuring success in the development of a given sector of the economy in a developing country is training. In Tunisia training of beekeepers is being carried out at all educational levels: elementary, secondary, vocational and higher.

Initially the Project focused its attention on the training of instructors. Over a one-year period (1976-1977) 150 teachers were taught beekeeping. Of these teachers, 11 were assigned to 11 primary schools that were suitably equipped with the aid of UNICEF. The primary schools in which the study of beekeeping was introduced were chosen in areas suitable for beekeeping. Some of their pupils (sons of beekeepers and farmers

who were not able to follow secondary-level theoretical studies) were directed toward the beekeeping sections of the Vocational Training Centres of the Ministry of Agriculture.

Three apiculture and arboriculture sections have already been set up. These were attended by 120 students during the academic year 1977/78. Courses last for two years and are followed by a one-year practical course within the framework of the Project.

Some of those completing the vocational training sections and the one-year course in production go on to develop the apiaries of their relatives, while others join together to establish new apiaries or find work in the private or public sectors.

A new training programme has been started on an experimental basis in co-operation with the Regional Commissariats for Agricultural Development and this seems to have excellent prospects. Students who finish their studies in a vocational training centre are sent on to a one-year course at the beekeeping pilot centres as trainees, and are financed by rural

development funds. When they set up as beekeepers in their own apiaries they receive 10 modern, stocked hives and working equipment financed by the same rural development funds or through bilateral co-operation. This programme will be encouraged as much as possible since it stimulates the new beekeepers to set up their own apiaries and avoids merely taking trainees and turning them into new officials searching for employment.

State-owned agricultural institutions needing more beekeepers also grant fellowships to young people in the area where the institution is located in order to enable them to attend production courses.

In order to raise standards, it is planned to extend the production course by one year, making it a minimum of two years. Professors of Natural Science in the agricultural colleges periodically attend refresher seminars. Beekeeping is also taught in the Higher Institutes for Agriculture and Veterinary Medicine.

Research activities are of an applied nature in order to resolve current problems raised by the develop-

ment of beekeeping. Thus, topics are studied in connection with the selection and improvement of local strains of bees, methods of conserving the queens during the summer and winter, techniques to increase the production of honey and beeswax and the prophylaxis and control of the diseases of bees.

Diagnosis and research in connection with the control of honeybee diseases are being carried out in the Rabta Pathological Laboratory. Research on morphobiology and behaviour in the production of local strains of honeybees (*Apis mellifica intermissa*) is under way. Previously, work on the selection and improvement of the local strain was neglected. In the Project's improvement studies four internationally reputed strains of honeybees, *Apis mellifica carnica*, *Apis mellifica carpatica*, *Apis mellifica caucazica* and *Apis mellifica ligustica*, are being used. The F_1 and F_2 hybrids obtained by two-way crossbreeding were more productive and possessed a greater resistance to disease as a result of heterosis, but in the F_3 aggressiveness increased compared

Traditional and modern hives





Beekeeper with his traditional hives



Modern beekeepers

with local strains. The pure, local strain of bees has proved more productive than the other strains mentioned, better adapted to local environmental conditions and therefore more suitable for brood rearing in Tunisia. A programme for the selection of this strain has been worked out and started. In addition, research into pollination and the improvement of honey-bearing plants is also being undertaken.

Extension work is being carried out by demonstration, films and the holding of beekeeping conferences at pilot centres.

In the research and extension fields these activities will become more widespread once the National Beekeeping Centre has been set up.

Some figures concerning the impact of the Project. In 1979 over 40 per cent of the operational expenses of the Project were covered by returns from production while in 1981 it is hoped that the coverage will be 100 percent.

By the end of the Project, beekeeping will have been taught to over 2 000 primary school pupils, over 1 000 students of vocational schools and agricultural colleges and to 500 senior staff (engineers and veterinary surgeons). Over 5 000 farmers and beekeeping enthusiasts participated in the beekeeping information days and practical demonstrations at the Project's pilot stations.

About 3 000 farming families will practise beekeeping with the assis-

tance of the Project and will obtain additional income varying between 400 and 800 dinars (approximately US\$ 1 000-2 000) a year. This will help improve standards of living and the settlement of young people on the land.

Beekeeping in other developing countries of the Mediterranean basin. A detailed description of beekeeping in the developing countries is difficult, owing to the absence of statistical data. However, some information has been gathered during recent FAO missions to some of these countries.

In the Libyan Arab Jamahiriya, for instance, about 20 000 colonies of honeybees imported from Italy (*Apis mellifica ligustica*) and Bulgaria (*Apis mellifica carnica*) have been distributed in the regions of Tripoli and Benghazi. During the years 1976-1977, because of the difficult environmental conditions and the fact that the strains of bees used had not adapted properly, the number dropped by 50 percent. Brood rearing in the Libyan Arab Jamahiriya suffers from lack of pollen for seven to nine months of the year, from parasitic and infectious diseases, from the lack of specialists to look after the bees and from the absence of an organization responsible for research, training and extension work. The local bee (*Apis mellifica intermissa*), which is very well adapted to the difficult local climatic condi-

tions, is neglected and is even in danger of extinction. The author was called upon to advise on these problems and to assist in the creation of a beekeeping section in the FAO Project TF-LIB-10 under the Gefara Plain Authority.

A team of nine Tunisian technicians trained under the Tunisian Project (now under the direction of a Tunisian) has been sent to this section which, with the Project's assistance, will become a national beekeeping development project in the Libyan Arab Jamahiriya.

In Algeria and Morocco, countries with exceptional honey-producing potential, it has not been possible so far to undertake beekeeping development. At present, each of these countries has some 15 000 to 20 000 colonies of honeybees in modern hives and 200 000 to 300 000 colonies in traditional hives, with production levels that are far from meeting domestic requirements.

The agro-climatic conditions of these countries would allow them each to rear about a million colonies of bees, and this could yield an output of honey in excess of domestic consumption needs, as well as producing a surplus that could be exported.

In Algeria, on the initiative of the University and Research Centre of Constantine, and following the example of Project TUN/75/005, a local beekeeping development programme has been projected, a feature

of which is the establishment of a beekeeping research institute. This initiative will need to be reinforced and extended to other regions of Algeria, such as Algiers and Oran.

In Morocco a beekeeping organization has been set up in Koudia, in the vicinity of Rabat, but no national beekeeping development programme has so far been initiated. Because of the remarkable honeybee-rearing potential of this country, honey production averaging 50-60 kg of honey a year per colony of bees could be achieved. The Tunisian Project would, of course, be willing to assist in the development of such a programme, through which Morocco could join the group of countries at present having the greatest production of honey.

In the Mediterranean basin Turkey is another country that has good



Hives in a modern apiary



Bees collecting nectar from one of the many species of eucalyptus trees found over the Mediterranean basin region

beekeeping conditions and potentialities for production of comparable magnitude to the above-mentioned countries.

In Lebanon the Tunisian Project is assisting in the development of a beekeeping project. Lebanon has at present about 15 000 colonies of honeybees (*Apis mellifica syriaca*), two thirds in modern hives and one third in traditional hives, yielding an output of honey that does not, however, exceed 23 percent of domestic consumption. Honey-producing resources are considerable, since the 14 000 ha of citrus fruits alone, for example, could accom-

modate a minimum of 42 000 colonies (3-5/ha), yielding an output that might leave a surplus for export.

Concurrently with this assistance to Lebanon, the Tunisian Project has been asked to participate in a similar programme in Syria, which was due to start in October 1979. Consideration is also being given to bee-rearing programmes on the islands of Cyprus and Malta.

Proposals for development of beekeeping in the Mediterranean basin. The experience acquired by Tunisia in the field of apiculture should be strengthened and made use of by all the developing countries of the Mediterranean basin.

For this purpose, the possibility of setting up a Regional Project to assist beekeeping development in these countries is under consideration. Such a project might be implemented in two stages — the first would have a preparatory function and would aim at strengthening the activities started by Project TUN/75/005 and ensuring FAO/UNDP assistance to the Tunisian National Centre for Research, Training and Advanced Training in Beekeeping, which could be equipped to play a pilot role on a regional basis for assisting the developing countries

in the Mediterranean basin. This Centre could then collaborate with the Ministries of Agriculture of Lebanon, Morocco and Syria in formulating and establishing national beekeeping projects, giving technical assistance to projects already existing in the Libyan Arab Jamahiriya and Algeria, and carrying out exploratory missions in Cyprus, Malta and Turkey. Such a Regional Centre could organize staff training and advanced training courses for the above-mentioned projects. The results of the scientific research carried out by the Tunisian Centre would need to be widely disseminated so that they could be utilized in beekeeping practices throughout the Region.

The second stage would be devoted to coordination and regional assistance for the purpose of achieving effective co-operation between the national beekeeping projects.

In conclusion, it should again be stressed that the developing countries of the Mediterranean basin have an exceptional potential for honey production, the development of which could best be assisted within the framework of a "Regional project for assistance to beekeeping development" such as has been described. Such a project could prove of incalculable value to the countries concerned. ■

Dried poultry waste as a feed ingredient

J. Biely, W.D. Kitts and N.R. Bulley

Animal wastes should be recognized as an active biomass, since they are products of metabolism in the same manner as are by-products of the feed industry that involve fermentation. Waste materials arising from many industries serving mankind, viz., chemical-related industry, paper and applied products, agricultural (primary) production and food industries, can no longer be ignored and allowed to pollute the environment. Waste materials are becoming more attractive as a source of nutrients that can be used to serve man beneficially.

The animal scientist is aware of the importance of animals, especially the ruminant (Reid, 1970), in meeting the world's expanding protein needs. The scientist is also aware of the environmental quality degradation associated with excrement from the intensified confinement systems used in livestock production. The solid waste from farm animals in the United States has been estimated at approximately two thousand million tons annually (Bhattacharya and Taylor, 1975). It was also estimated that 50 percent of these wastes are produced through intensive animal production systems. The traditional method of disposing of animal waste for crop production has been replaced by the relative convenience and availability of inorganic fertilizers.

Animal waste is a fragile product

The authors are with the University of British Columbia, Vancouver, BC V6T 1W5, Canada. The authors are greatly indebted to Dr P. Stapleton for research he carried out as a post-doctoral researcher in poultry science.

TABLE 1. Animal waste characteristics

Item	Chickens	Hogs	Cattle
Animal size (kg)	1.8-2.2	44.6	446.4
Wet manure (kg)	0.05-0.17	1.3-4.2	17.2-33.0
Total solids (% wet basis)	25-48	12-28	13-27
Total solids (kg/day)	0.02-0.04	0.36-0.71	4.2-5.09
Volatile solids (% dry basis)	74-79	83-87	—
Nitrogen (kg/day)	5.4×10^{-4} - 2.5×10^{-3}	0.019-0.027	0.16-0.20
P ₂ O ₅ (kg/day)	4.5×10^{-4} - 2.0×10^{-3}	0.01-0.014	0.049-0.0053
K ₂ O (kg/day)	2.2×10^{-4} - 8.5×10^{-4}	0.015-0.276	0.12-0.15

Source: Loehr, 1969.

subject to rapid changes in chemical composition caused by the physical environment and by microbial action. Nutrient content changes rapidly with time after excretion, as does the concentration of other compounds. The characteristics of wastes derived from animal and poultry production are given in Table 1. The nutrients found in these wastes (Table 2) may be better utilized directly as a feed for poultry and livestock than by being returned to land as a source of nutrients for plants. The shortage of feed protein

for animal ration purposes in recent years and the expected recurrence of this shortage is sufficient reason to continue research activities on the recycling of animal wastes as feed-stuffs.

Dehydrated poultry waste. The term "dehydrated poultry waste" (DPW), as defined here, refers to ambient and high-temperature dried wastes, which include droppings and spilled feed from cage layers as well as, in certain circumstances, feathers and broken

TABLE 2. Nutrients in animal wastes
Percentage, dry basis

Nutrient	Cattle	Hog	Sheep	Horse	Hen
N	0.3-1.3	0.2-0.9	0.9	0.66	1.8-5.9
P ₂ O ₅	0.15-0.5	0.14-0.83	0.34	0.23	1.0-6.6
K ₂ O	0.13-0.92	0.18-0.52	1.0	0.68	0.8-3.3

Source: Loehr, 1969.



"Poultry-house litter" from intensive production in Lebanon



Pure poultry manure from caged layers falling directly on the floor

eggs. An important cause of the wide variation of the chemical composition of DPW is the duration of storage of the wet manure (see graph).



(SOURCE: Flegal, Sheppard and Dorn, 1972)

Effect of storage duration of fresh hen droppings on crude protein content of dried poultry waste.

The use of DPW in animal rations serves two main purposes: it decreases the total amount of manure to be disposed of and it may serve as an economical source of nutrients for animals.

Composition. Before any feed ingredient can be incorporated into an animal ration, it is necessary that its exact composition be known. Several groups of researchers have determined the nutrient composition of DPW and a summary of the results is presented in Table 3. It will be noted that there are remarkable similarities in the composition of all four samples with the exception of calcium in the sample from Canada (Stapleton and Biely, 1975), which was obtained from four-week-old cockerels, the other samples being obtained from layers. These remarkable similarities are due, no doubt, to a great extent to the modifying action of micro-organisms in the intestinal tract on non-digested feed.

The chemical composition of DPW can be summarized as follows: it has a high nitrogen content, containing about 25 percent crude protein (but only half of this is true protein); uric acid is the major non-protein nitrogenous substance. The fat content is generally low, ranging from 2 to 4 percent. Fibre is high with a content of 10 to 14 percent. The ash content of DPW from layers is high (25-35 percent), while the DPW from cockerels is much lower, due to a lower calcium and phosphorus content. The amino

TABLE 3. Chemical analysis of DPW
Percentage

Item	DPW			
	Netherlands ¹	Canada ²	USA ³	United Kingdom ⁴
Moisture	4.5	9.4	7.3	9.6
Crude protein	24.3	25.5	24.2	27.0
True protein	14.7	14.2	10.8	10.6
Non-protein nitrogen (N × 6.25)	9.5	11.3	13.4	16.4
Uric acid	—	7.1	—	5.7
Ether extract	4.1	3.1	2.1	1.8
Fibre	10.1	12.0	13.7	14.9
Ash	35.8	—	26.9	26.5
Calcium	10.6	2.1	7.8	7.4
Phosphorus	2.7	1.4	2.6	2.1
Potassium	2.4	1.8	1.9	1.3
Copper	—	0.0063	—	0.0057
Iron	—	0.113	—	0.18
Manganese	—	0.044	—	0.029
Zinc	—	0.068	—	0.029
Magnesium	—	0.42	—	0.64

Sources: ¹ DPW from layers; Boushy and Vink, 1977. — ² DPW from cockerels (four-week-old); Stapleton and Biely, 1975. — ³ DPW from layers; Flegal and Zindel, 1970. — ⁴ DPW from layers; Blair and Knight, 1973a.

TABLE 4. Amino acid composition of DPW
Percentage

Amino acid	DPW				
	Netherlands ¹	Canada ²	USA ³	United Kingdom ⁴	Barley
Lysine	0.56	0.51	0.49	0.39	0.40
Histidine	0.19	0.18	0.20	0.19	0.29
Arginine	0.53	0.47	0.47	0.41	0.59
Aspartic acid	1.22	0.63	1.06	0.83	—
Threonine	0.60	0.49	0.50	0.40	0.42
Serine	0.72	0.46	0.52	0.43	0.42
Glutamic acid	1.69	1.53	1.54	1.26	—
Glycine	0.93	1.83	0.82	0.51	0.40
Alanine	1.07	0.54	1.06	0.71	—
Valine	0.83	0.61	0.62	—	0.62
Methionine	0.29	0.13	0.09	0.12	0.17
Isoleucine	0.66	0.47	0.50	0.37	0.49
Leucine	0.94	0.73	0.80	0.60	0.80
Tyrosine	0.40	0.24	0.26	0.27	0.33
Phenylalanine	0.53	0.45	0.45	0.36	0.64
Cystine	0.21	0.11	1.09	0.21	0.19
Proline	—	0.69	—	0.57	—

Sources: ¹ DPW from layers; Boushy and Vink, 1977. — ² DPW from cockerels (four-week-old); Stapleton and Biely, 1975. — ³ DPW from layers; Flegal and Zindel, 1970. — ⁴ DPW from layers; Blair and Knight, 1973b.

acid composition of DPW is shown in Table 4.

Protein utilization. Research work on the evaluation of the protein quality of DPW for chicks or other monogastric animals is scarce. The amount of non-protein nitrogen (NPN) in DPW (47 to 64 percent of total nitrogen on a dry weight basis) limits its protein value for non-ruminants. The uric-acid nitrogen in DPW, which ranges from 30 to 60 percent of the NPN in DPW, is not utilized by poultry (Blair, 1972); as a matter of fact, as shown in Table 3, dried poultry excreta contains 5.7 to 7.1 percent uric acid. Bose and Gosh (1945) and Baker (1946) showed that uric acid in DPW ranges between 4 and 10 percent.

The true protein content of DPW is similar to that of cereal grains. The lysine, arginine, cystine and methionine levels in DPW compare very well with the levels of these amino acids in barley (Table 4). These results indicate that DPW may have a protein value comparable to cereal grains such as barley.

The crude protein (CP) value of DPW has been shown to be about 53

percent digestible when fed as a main (90 percent) source of protein in adequate rations for sheep (Tinnitmit *et al.*, 1972). Other reports, however, have assigned a higher protein digestibility to DPW for ruminants. Bull and Reid (1971) gave a CP digestibility value of 73 percent for DPW while Lowman and Knight (1970) reported a value of 77 percent CP digestibility for DPW in sheep.

Smith and Calvert (1972) substituted DPW for 0, 50 and 100 percent of the soybean meal in sheep rations. Their results showed no difference between the three diets in digestibility of dry matter and CP and they concluded that the use of DPW as a protein source produced average daily gains at least 90 percent as great as soybean meal.

Energy utilization. When evaluating the potential of any feedstuff as an ingredient of a ration, the energy content as well as the protein content must be considered. Much less information is available regarding the actual metabolizable energy (ME) level of DPW. It is safe to say that the ME values are very low, since the fat content is low, while the fibre and uric

acid levels are high. Fibre and uric acid may be regarded as substances containing little or no utilizable energy. Blair (1974) gives an ME value of 850 kcal/kg, while Yoshida and Oshii (1965) found that DPW had a metabolizable energy content of 1 840 kcal/kg for chicks. A somewhat similar value was given by Lowman and Knight (1970). Shannon, Blair and Lee (1973) added to the confusion and the uncertainty when they found that the ME of DPW varied from 640 to 1 270 kcal/kg. On the basis of these values, it seems safe to say that DPW may have a maximum ME of about 1 800 kcal/kg and a minimum of about 600 kcal/kg. The low ME value of DPW may pose a severe barrier to the routine incorporation of DPW into high-energy poultry rations. It may, however, have beneficial effects on chick growth after they have reached eight weeks of age and on breeder broilers.

Dried poultry wastes have a digestible energy (DE) value of 2 000 kcal/kg for sheep and cattle, making it approximately equivalent to a good quality hay. El-Sabban *et al.* (1970) reported that the addition of cooked or autoclaved poultry waste did not

TABLE 5. The chemical composition of DPW after recycling five times

Composition	DPW from basal ration	1st recycle	2nd recycle	3rd recycle	4th recycle	5th recycle
Total nitrogen (%)	4.46	4.61	4.80	5.38	5.33	4.75
Non-protein nitrogen (%)	2.36	2.49	2.65	3.38	3.28	2.65
True protein (%)	13.12	13.25	13.43	12.50	13.12	13.00
Fibre (%)	14.00	13.30	12.40	10.40	10.30	10.50
Lignin (%)	7.38	7.10	5.81	6.32	6.41	6.16
Fat (%)	3.04	4.82	7.07	6.81	7.08	9.60
Uric acid (%)	7.10	5.76	6.69	7.34	5.96	7.24
Calcium (%)	1.94	1.39	1.24	1.15	1.01	0.88
Phosphorus (%)	1.88	1.24	1.24	1.18	1.12	1.10
Cu (ppm)	63.00	71.00	75.00	75.00	71.00	80.00
Fe (ppm)	1 130.00	1 012.00	869.00	886.00	699.00	958.00
Mn (ppm)	436.00	572.00	525.00	558.00	576.00	456.00
Zn (ppm)	683.00	825.00	969.00	940.00	1 147.00	1 158.00
Mg (%)	0.42	0.50	0.53	0.58	0.49	0.41
K (%)	1.79	2.07	2.15	2.27	2.18	1.90

Source: Stapleton and Biely, 1975.

TABLE 6. Amino acid composition of recycled DPW
Percentage

Amino acid	DPW from 20% basal	1st recycle	2nd recycle	3rd recycle	4th recycle	5th recycle
Aspartic acid	0.63	0.61	0.60	0.62	0.61	0.60
Threonine	0.49	0.42	0.49	0.46	0.45	0.48
Serine	0.46	0.48	0.51	0.43	0.43	0.45
Glutamic acid	1.53	1.44	1.29	1.39	1.43	1.37
Proline	0.69	0.87	0.87	0.65	0.65	0.59
Glycine	1.83	1.12	1.86	3.04	3.54	2.11
Alanine	0.54	0.55	0.53	0.53	0.53	0.54
Valine	0.61	0.53	0.51	0.60	0.60	0.56
Cystine	0.11	0.10	0.11	0.11	0.11	0.12
Methionine	0.13	0.15	0.18	0.13	0.13	0.17
Isoleucine	0.47	0.42	0.41	0.47	0.47	0.46
Leucine	0.73	0.69	0.66	0.72	0.72	0.73
Tyrosine	0.24	0.24	0.28	0.26	0.28	0.23
Phenylalanine	0.45	0.40	0.37	0.44	0.44	0.43
Lysine	0.51	0.51	0.53	0.51	0.51	0.52
Histidine	0.18	0.14	0.14	0.17	0.18	0.16
Arginine	0.47	0.43	0.37	0.42	0.40	0.41
TOTAL	10.07	9.10	9.71	10.95	11.48	9.93

Source: Stapleton and Biely, 1975.

change the DE value of a purified sheep ration when incorporated at approximately 25 percent of the diet in place of soybean meal.

Stapleton and Biely (1975) examined the chemical composition of poultry manure from chicks being fed a starter ration containing 10 or 20 percent DPW. The manure from the birds was collected, dried and refeed through five cycles. The chemical composition of the DPW and its amino acid composition is given in Tables 5

and 6. Perhaps the most outstanding feature of the data presented in the two tables is the unchanging composition of the DPW with successive recycling. The only nutrients that appeared to increase in concentration in the DPW were zinc and copper. However, the increases could not be considered dramatic or even potentially harmful. The fat level in the fifth recycle of DPW was 9.6 percent, while the DPW from a basal ration was only 3.04 percent.

The fibre content decreased somewhat with successive recycles while most other nutrients, including true protein, remained constant. The amino acid composition of the DPW did not change with continual recycling of the chick excreta. It seems that only the metabolizable energy content of DPW is subject to any appreciable variation. The other nutrients remain at a relatively constant level, irrespective of the source of the DPW and the recycling of the waste products.

TABLE 7. Effect of various levels of DPW on egg production

Percent of DPW in diet	Hen-housed production (%)	Hen day production (%)	Feed efficiency (kg feed/dozen eggs)	Egg weight (g)	Shell thickness (mm)	Haugh score
0	58.2	64.7	1.95	63.04	0.3254	67.76
10	61.2	65.4	1.96	62.17	0.3167	74.44
20	57.3	62.8	2.09	61.92	0.3162	71.28
40	55.4	57.0	5.17	61.77	0.3241	76.78
40 (+ fat)	53.2	59.0	2.29	60.63	0.3119	73.05

Source: Flegal and Zindel, 1971.

The effect on layer productivity of incorporating DPW into layer rations has been examined by several groups of researchers. Flegal and Zindel (1971) fed laying hens diets containing from 0 to 40 percent DPW. The results obtained are shown in Table 7. The highest percentage of egg production (61.2 percent) was obtained from birds receiving 10 percent DPW in their ration. There were no statistically significant differences in hen-housed egg production but a definite trend

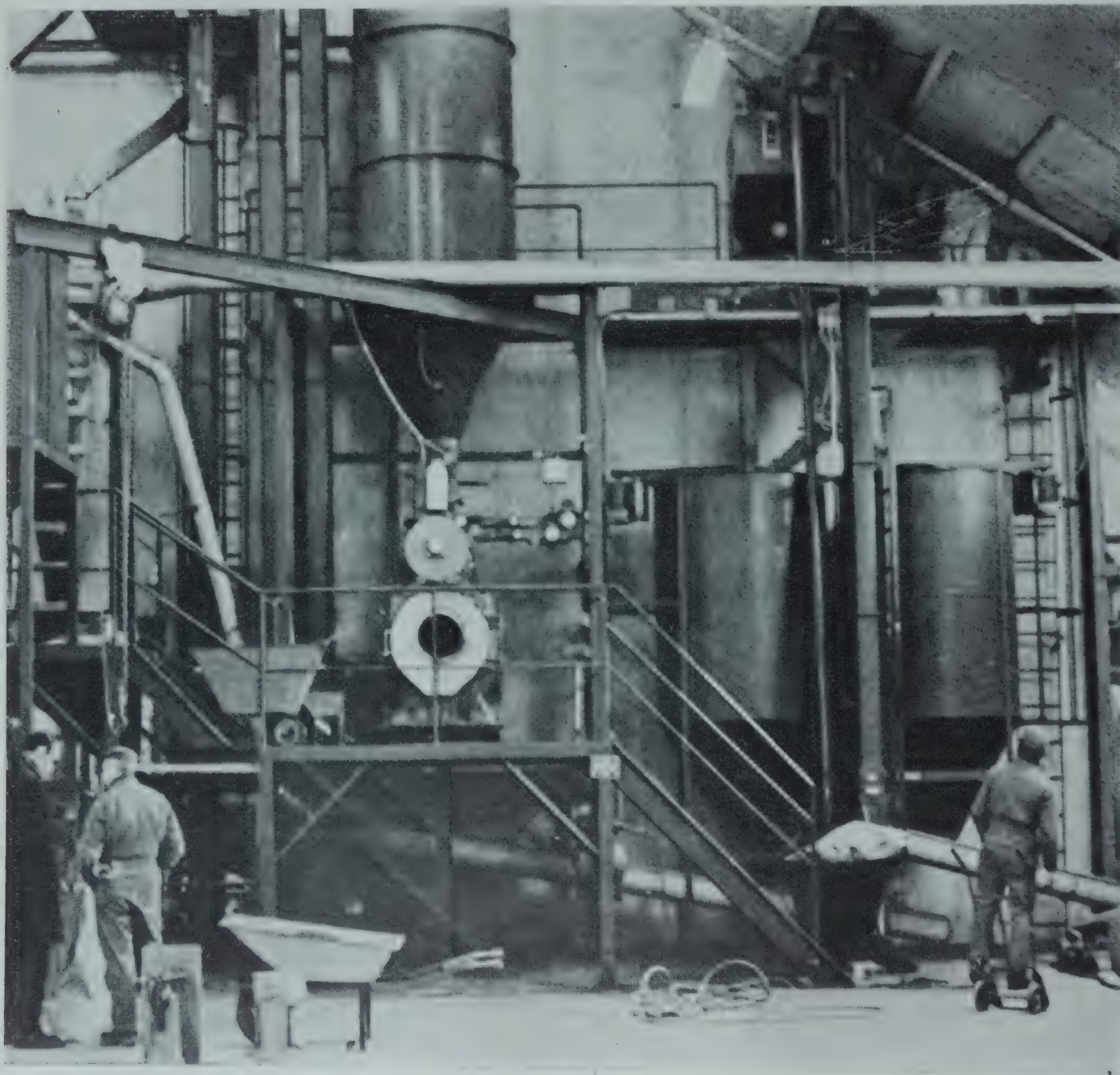
toward lower values was observed as the DPW content of the ration increased. Feed efficiency was inversely proportional to the DPW content of the diet. Egg weight and shell thickness tended to decrease as DPW in the ration increased, but, again, changes were not significant. Egg production and organoleptic quality of eggs were not affected by the incorporation of DPW in the diet up to 20 percent.

Similar findings were reported by

Galal, Johnson and Norton (1977). With these and other reports (Waldroup and Hazen, 1974) there seems to be general agreement that rations containing 10 percent DPW will not adversely affect egg production, egg size or egg quality. Energy is the limiting factor in DPW.

As regards DPW and chick growth, three groups of researchers (Boushy and Vink, 1977; Flegal and Zindel, 1971; and Biely *et al.*, 1972) have shown that when DPW is added to the

Delivery of a new Danish drier, which pasteurizes and pellets 4-5 tons of feed supplement an hour. DPW can substitute for up to 40 percent of beef rations, and 20 percent or more in poultry feed.



ration, the efficiency of feed utilization is decreased. There seems, however, disagreement as to the effects of DPW on growth. This lack of agreement could be due to variations in protein and caloric content of the rations used.

Geri (1968) reported that the incorporation of 10 percent DPW in a growing ration fed to swine for 56 days (initial weight 32 kg) did not result in any significant change in average daily gain or feed efficiency.

(1.45 kg) and feed efficiency (5.7) did not change as a result of replacing 25 percent sunflower oil meal by 21 percent DPW in a fattening ration. Recently Oliphant (1974) showed that the feeding of DPW as the sole protein supplement for barley in beef rations did not change average daily gains of beef steers, while Smith (1974) observed no difference in dry matter intake, average daily gains, feed efficiency, and nutrient utilization between cattle fed maize meal con-

Salmonella spp. Alexander, Carrier and McKay (1968) found a wide range of organisms in poultry litter but most of these were normal inhabitants of the intestinal tract of animals. Overall it seems that the disease hazard from dried poultry waste is minimal.

Messer *et al.* (1971) reported low concentrations of pesticides and medicinals in poultry litter. However, they stressed that higher levels might be present and that the effects, if any, of such levels are as yet unknown.

TABLE 8. Bacteriological examination of DPW samples

Sample no.	Type of drier	Direct culture	Selenite broth culture
1	Orm	Few anthracoid bacilli	Paracolon bacilli
2	Orm	Few anthracoid bacilli	Paracolon and anthracoid bacilli
3	Coleman	No organisms isolated	Paracolon bacilli
4	Haro	Few paracolons and anthracoid bacilli	Anthracoid bacilli
5	Fletcher	No organisms isolated	No organisms isolated
6	Sturtevant	Few anthracoid bacilli	Anthracoid bacilli
7	Fletcher	Several staphylococci	Staphylococci and anthracoid bacilli
8	Thormbers	Few <i>E. coli</i> and anthracoid bacilli	—
9	Sample 8 (autoclaved)	Few anthracoid bacilli	—

Source: Shannon, Blair and Lee, 1973.

However, incorporation of even 7 percent DPW in a starter ration for swine resulted in marked depression of body-weight gain beginning at 17 kg body weight and after feeding for 23 days. The results obtained here were probably due to the lack of adaptation of the animals to the diet.

A number of reports (Rodrigues and Zorita, 1967; El-Sabban *et al.*, 1970; Meregalli *et al.*, 1972; and Tagari *et al.*, 1976) show satisfactory use of DPW in beef production. Rodrigues and Zorita (1967) showed that when 55 percent DPW replaced an equal amount of a mixture of barley, an oilseed meal and wheat bran in a cattle-fattening ration, the DPW-fed group gained 78 percent as much as the controls did. Meregalli *et al.* (1972) reported that average daily gains

taining 12.8 percent cotton seed meal and those whose feed contained 20.5 percent DPW.

Health hazards. The bacteriological composition of dried poultry manure from layers was determined by Shannon, Blair and Lee (1973) and the results are shown in Table 8. Direct culture of nine samples revealed that, although the samples were not sterile, the numbers of organisms were so small as not to constitute a disease hazard. Culture in selenite broth showed that none of the samples was contaminated with Salmonella species. It seems that the drying conditions used partially sterilize the DPW. Kraft *et al.* (1969) reported that about 25 percent of the samples of freshly voided excreta were contaminated with

TABLE 9. Composition of broiler litter

Dry matter (%)	84.7
Composition of dry matter	
Crude protein (%)	31.3
True protein (%)	16.7
Digestible protein (%)	23.3
Percent digestibility (%)	74.6
Crude fibre (%)	16.8
Ether extract (%)	3.3
NFE (%)	29.53
DE (sheep) (kcal/kg)	2 440
ME (sheep) (kcal/kg)	2 181
Total digestible nutrients (sheep) (%)	72.5
Ash (%)	15
Calcium (%)	2.37
Phosphorus (%)	1.8
Potassium (%)	1.78
Copper (mg/kg)	98
Iron (mg/kg)	451
Manganese (mg/kg)	225
Zinc (mg/kg)	235
Magnesium (%)	0.44

Source: Bhattacharya and Taylor, 1975.

Poultry-house litter (broiler litter).

The manure from poultry houses, where birds are maintained on litter, is designated as "poultry-house litter". The nutrient composition of broiler litter is shown in Table 9. Many factors contribute to the wide range of chemical variation found in this product. Elements of standard management systems, such as bedding used (i.e., maize cobs, peanut hulls, rice hulls, wood shavings) are the main

source of variation. Broiler litter is valuable mainly for its nitrogen content, since studies (Fontenot *et al.*, 1971) have shown that the average crude protein content is about 30 percent on a dry weight basis. The broiler litter is usually high in fibre (15 percent), the major constituent being lignin, as well as ash (15 percent), with comparatively higher amounts of both calcium and phosphorus compared with natural feed-stuffs. Much of the crude protein (50 percent) seems to be composed of true protein that is high in glycine and somewhat low in arginine, lysine, methionine and cystine (Bhattacharya and Fontenot, 1966).

The DE value of broiler litter in sheep is about 2 440 kcal/kg which compares favourably with 2 479 kcal/kg for alfalfa hay. The ME value of

the litter is reported to be 2 181 kcal/kg dry matter (Bhattacharya and Fontenot, 1966). The DE of wood shaving litter was found to be about 2 000 kcal/kg in cattle (Brugman *et al.*, 1964).

Conclusions. The poultry and livestock industry on the North American continent has achieved a high level of production efficiency. The volume and efficiency of this industry will no doubt be expanded further to feed future generations. If processed animal wastes are to be used as a feed ingredient, the question of its actual feeding value arises. If wastes are of high enough feeding value to replace substantial amounts of nitrogen and phosphorus then they can be evaluated in terms of the amount of material that can be saved. Thus, the material these wastes replace would be free for

domestic use or for export. As mentioned initially the total amount of animal wastes estimated in the United States is about 2 thousand million tons annually. These wastes include 200 million tons of poultry waste, and 1 075 million tons of goat, sheep and horse waste. It is estimated that 50 percent of these wastes may be made available for use in recycling into animal feeds.

These wastes are most efficiently utilized by ruminants but can also be used in balanced poultry rations. When properly processed, animal wastes do not impart any objectionable odours or tastes to the finished product. Information at present available suggests that waste material can be safely and profitably recycled, by feeding, without hazard to animal health. ■

References

- ALEXANDER, D.C., CARRIER, J.A.J. & MCKAY, K.A. 1968. *Can. vet. J.*, 9: 27.
- BAKER, C.J.L. 1946. *Poultry Sci.*, 25: 593.
- BHATTACHARYA, A.N. & FONTENOT, J.P. 1966. *J. Anim. Sci.*, 25: 367.
- BHATTACHARYA, A.N. & TAYLOR, J.C., 1975. *J. Anim. Sci.*, 41: 1 438.
- BIELY, J., SOONG, R., SEIER, L. & POPE, W.H. 1972. *Poultry Sci.*, 51: 1 502.
- BLAIR, R. 1972. *World Poultry Sci. J.*, 29: 189.
- BLAIR, R. 1974. *Proceedings of the 15th World's Poultry Congress, New Orleans, USA*: 225-227.
- BLAIR, R. & KNIGHT, D.W. 1973a. *Feed-stuffs*, 45(10): 32-33.
- BLAIR, R. & KNIGHT, D.W. 1973b. *Feed-stuffs*, 45(12): 31-33.
- BOSE, S. & GHOSH, D.B. 1945. *Poultry Sci.*, 24: 146.
- BOUSHY, A.R. & VINK, J.W.A. 1977. *Feed-stuffs*, 49: 24.
- BRUGMAN, H.H., DICKEY, H.C., PLUMMER, P.E. & POULTON, B.R. 1964. *J. Anim. Sci.*, 23: 869. (Abstract)
- BULL, L.S. & REID, J.T. 1971. In *Livestock waste management and pollution abatement. Proceedings of the International Symposium on Livestock Wastes, Columbus, Ohio, USA*: 297-300.
- EL-SABBAN, F.F., BRATZLER, J.W., LONG, T.A., FREA, D.E.H. & GENTRY, R.F. 1970. *J. Anim. Sci.*, 31: 107.
- FLEGAL, C.J. & ZINDEL, H.C. 1970. *Research report No. 117*, p. 21-28. East Lansing, Michigan State Agricultural Experiment Station.
- FLEGAL, C.J. & ZINDEL, H.C. 1971. In *Livestock waste management and pollution abatement. Proceedings of the International Symposium on Livestock Wastes, Columbus, Ohio, USA*: 305-307.
- FONTENOT, T.P., WEBB, K.E. JR., HARMON, B.W., TUCKER, R.E. & MOORE, W.E.C. 1971. In *Livestock waste management and pollution abatement. Proceedings of the International Symposium on Livestock Wastes*: 301.
- GALAL, A.C., JOHNSON, H.S. & NORTON, H.W. 1977. *Poultry Sci.*, 1 670-1 673.
- GERI, G. 1968. *Alimentazione animali*, 12: 559.
- KRAFT, D.J., OLECHOWSKI-GERHARDT, C., BERKOWITZ, J. & FINSTEIN, M.S. 1969. *Applied Microbiol.*, 18: 703.
- LOEHR, R.C. 1969. *J. San. Eng. Div. SA2*, p. 189.
- LOWMAN, B.G. & KNIGHT, D.W. 1970. *Anim. Prod.*, 12: 525.
- MEREGALLI, A., OLIVETTI, A., ANTONGIOVANNI, M., GUALTIERI, M. & BIAGIOLI, O. 1972. *Alimentazione animali*, 16: 21.
- MESSER, J.W., LOVITT, J., MURTHY, GOPALA, K., WEIHYBY, ALBERT, J., SCHAFER, MARY L. & READ, R.B. JR. 1971. *Poultry Sci.*, 50: 874.
- OLIPHANT, J.M. 1974. *Anim. Prod.*, 18: 221.
- REID, J.T. 1970. The future role of ruminants in animal production. In Phillipson, A.T., ed. *Physiology of digestion and metabolism in the ruminant*, p. 1-22, Newcastle-Upon-Tyne, Oriel Press.
- RODRIGUES, G.J. & ZORITA, T.E. 1967. *Revta Nutr Anim.*, 5: 25.
- SHANNON, D.W.F., BLAIR, R. & LEE, D.J.W. 1973. *Fourth European Poultry Conference, London*: 487-494.
- SMITH, L.W. 1974. *J. Anim. Sci.*, 39: 139. (Abstract)
- SMITH, L.W. & CALVERT, C.C. 1972. *J. Anim. Sci.*, 35: 275. (Abstract)
- STAPLETON, P. & BIELY, J. 1975. *Can. J. Anim. Sci.*, 55: 595.
- TAGARI, H., LEVY, D., HOLZER, C. & HAN, D. 1976. *Anim. Prod.*, 23: 317-327.
- TINNITMIT, P., YU, Y., MCGUFFY, K. & THOMAS, J.W. 1972. *J. Anim. Sci.*, 35: 431.
- WALDROUP, P.W. & HAZEN, S. 1974. *Arkansas Farm Research*, 23(3).
- YOSHIDA, A. & OSHII, H. 1965. *Jap. Poultry Sci.*, 5: 37.

The location of literature on rabbit research

D.D. Caveny and H.L. Enos

The increasing importance of producing rabbits for meat in both developing and developed countries lends added interest to this description of a useful working approach to computerized resource-information file-systems prepared by workers at Colorado State University. Grant support was given to these workers to gather information throughout the world and to develop an educational programme on the commercial aspects of, and outlook for, rabbit production.

The rabbit was considered a food animal during the two World Wars but during the 1950s and 1960s, interest in the rabbit as a meat animal in the United States decreased substantially. President Lyndon B. Johnson closed the US Rabbit Experiment Station, Fontana, California, in the 1960s. Subsequent to the closing of the Fontana Station, a renewed interest in the rabbit as a meat animal has developed throughout the world. Research pertaining to commercial meat production and management of large rabbitries is presently being conducted on an international scale. In Hungary (Holdas and Petohazi, 1975; Holdas, 1978), there are two large-scale commercial rabbitries with over 10 000 does per farm. The French (Anon., 1974) Government has a research station where genetic management and nutritional studies related to rabbits are conducted. The Federal Republic of Germany, Italy, Spain and the United Kingdom also have organized government-sponsored research programmes. The United States research effort made during the 1970s is not organized and is fragmented at best under various specialized governmental programmes and at a few universities. The location of literature pertaining to the scattered reports of research has been a tedious undertaking.

When the authors began the first

bibliography (Caveny and Enos, 1972), many man-hours were spent searching abstracts and journals for the keyword "rabbit". Since the advent of computer searches, the work has become less tedious. A computer search in 1978 of the Commonwealth Agricultural Bureaux (CAB) publications yielded 1 500 entries pertaining to rabbit production published since 1972. A more recent search for 1978 and 1979 yielded an additional 415 entries. There are now two excellent avenues by which a literature resource file can be assembled: by a computer literature-search of commercially available systems through a university library or from a computer file company; and through the Current Awareness Literature Service (CALS) provided by the United States Department of Agriculture — Science Education Administration (USDA-SEA).¹

Commercial systems offer several advantages depending on the specific files searched. Printed copy can be received on-line or off-line through the postal system. Searches can be accomplished in a matter of minutes by these systems. Various formats for printed copy may be obtained. One system offers a choice of author,

Dr Caveny, is with the Department of Animal Science, Oregon State University, Corvallis, Oregon 97331, USA, and Dr Enos, is Associate Professor, Department of Animal Sciences, Colorado State University, Fort Collins, Colorado 80523, USA. This short communication has drawn on a considerable amount of research supported by a subcontract grant from the Four Corners Regional Commission, Albuquerque, New Mexico. It was also a symposium presentation at the 71st Annual Meeting of the American Society of Animal Sciences, Tucson, Arizona, in July 1979. This short communication appears as Colorado State University Experiment Station General Series Paper No. 2468 under the title *A working file of rabbit literature resources.*

¹ Editorial note: The Agrindex system described in issue No. 32 of this journal also provides a similar service.

title and journal, or printed abstracts of papers cited. The abstracts of foreign-language papers are printed in English and the language of the paper is noted as well as summary languages. The printed abstracts can then be duplicated by the subscriber and filed under subject, author and title for rapid reference.

The CALS search (USDA-SEA) provides a unique service to university researchers by searching several data bases from a profile sheet. To use this system the profile sheet is obtained from the USDA-SEA, Technical Information Systems, National Agricultural Library (NAL) Building, Beltsville, MD 20705 and returned to them. The NAL computer then searches any or all of the following: biological abstracts; chemical abstracts; engineering abstracts; National Agricultural Library Catalogue (CAIN); Commonwealth Agricultural Bureaux (CAB); food science and technology abstracts; and Government reports announcements. A printed list of articles may be received by the researcher from USDA-SEA on a monthly basis. This service may be used on a one-time basis, but may be updated monthly for comprehensive value. In general, the CALS search will continue monthly, for a nominal fee, until cancelled by the subscriber.

Complete information on search-profiles may be obtained from USDA-SEA or other systems. Researchers utilizing these searches must realize that computer data-bases are not perfect, but that they represent an extension of manpower. Since computer data-base systems are relatively new, summaries, abstracts and papers may reappear in the output of subsequent searches because they may appear in more than one data-base file. These duplications may be frustrating to the user although the benefits of a comprehensive resource-file certainly reward the researcher's time and effort.

Computer searching may also generate some non-relevant citations, which, however, may be minimized by careful selection of keywords. For example, one search conducted by the authors generated information on

rabbit-eye blueberries. Another search using keywords "rabbit" and "disease" produced many references to insect-borne diseases that were studied using the rabbit as a host. Also, dissertations from foreign countries may not be abstracted and, therefore, will not appear. The computer will not solve all information-resource needs; the researcher should determine which scientists publish extensively and establish correspondence with them so as to obtain current information in a specific subject area.

The establishment of a profile is the first and most important step in beginning a literature-resource file (LRF). The authors have found that a careful selection of keywords with the assistance of the librarian in charge of computer searches of data-bases saves much time and trouble compared with a "quick" trip to the computer terminal without careful keyword preparation. The authors have had good success obtaining useful rabbit-production information with the following keywords: rabbit(s); *Oryctolayus cuniculus*; production; management; nutrition; genetic(s); and reproduction. The addition of keywords such as growth and feeding have produced many papers not only on rabbit growth and feeding but also on insects that can be grown or fed on rabbits under laboratory conditions.

The computerized literature search has aided the researchers in obtaining information on rabbits from many diverse sources. It has also allowed the scientist to spend less time searching for information and more time conducting research. Progress in database information systems will allow more specific identification of subject matter and result in fewer non-relevant citations being received in the future. The microfiche is valuable in enabling the researcher to condense files. Species-oriented international associations enable the scientist to locate other individuals interested in similar research areas.

The following prepared bibliographies are useful to rabbit researchers:

CAVENY, D.D. & ENOS, H.L. 1979. *A bibliography of the domestic rabbit*. Fort Collins, Cooperative Extension Service,

Colorado State University, Bull. 481a (revised)

COMMONWEALTH BUREAU OF ANIMAL BREEDING AND GENETICS.

— *The effect of environment on the rabbit, 1933 to 1970*. (ABA Vol. 1 through 38). Annotated bibliography No. 150. 69 references. Price: £ 1.30.

— *The effect of environment on the rabbit, 1968 to 1972*. Annotated bibliography No. 150a. 13 references. Price: 70p.

— *AI in rabbits, 1969 to 1970*. Annotated bibliography No. 151. 38 references. Price: 70p.

— *Genetic aspects of reproduction in the rabbit, 1957 to 1973*. Annotated bibliography No. 235. 43 references. Price: 60p.

JONES, J.B. & BAILEY, D.E. 1971. *Disease of domestic rabbit. A bibliography*. *Laboratory Animals*, 5: 207-212.

MAKEPEACE, L.I. 1956. *Rabbits, a subject bibliography*. Fort Collins, Colorado State University Library.

Proceedings of the Rabbit Health Symposium. 1979. Fort Collins, Colorado State University Library.

WORLD RABBIT SCIENCE ASSOCIATION. *Rabbit diseases. Annotated bibliography with 353 references from 1977 to 1978*. Tynning House, Shurdington, Cheltenham.

The World Rabbit Science Association was founded in 1972. The first congress was conducted in France in 1976. The next congress will be held in Spain in 1980. The organization provides lists of members throughout the world and publishes a newsletter on activities and meetings.

References

ANON. 1974. Utilisez des lapins mâles améliorateurs. *Elevage*, 33: 113-118.

CAVENY, D.D. & ENOS, H.L. 1972. *A bibliography of the domestic rabbit*. Fort Collins Cooperative Extension Service, Colorado State University. Bull. 481a (revised)

HOLDAS, S. & PETOHAZI, G. 1975. Neue Rassen und Formen der Kaninchenhaltung in Ungarn. *Internationale Zeitschrift der Landwirtschaft*, 4: 429-432.

HOLDAS, S. 1978. Neues System der Kaninproduktion in Grossanlagen. *Internationale Zeitschrift der Landwirtschaft*, 7: 73-75.

FAO seminar on veterinary epidemiology, diseases-surveillance systems and economics of disease control

The above seminar was held in Bali, Indonesia from 17 to 21 September 1979. The seminar was attended by the Directors of Veterinary Services (or their equivalents) from Burma, Ethiopia, Ghana, Indonesia, Malaysia, Nigeria, Pakistan, Philippines, Sri Lanka, Tanzania, Thailand and Turkey; representatives from the Australian Development Assistance Bureau (2), German Technical Assistance Agency (3), Japanese International Cooperation Agency (4), Organization of African Unity, Office international des épizooties, USAID, staff of the FAO/CIDA Trust Fund project "Strengthening of animal health services in the Eastern Islands" and 75 officers from the Veterinary Service of Indonesia.

The objectives of the seminar were to familiarize directors of veterinary services and supervisors of projects within technical assistance agencies with the possibilities of improving disease-control systems in developing countries through the application of modern epidemiological methodology and veterinary economics.

The seminar commenced with a number of introductory lectures followed by a series of case studies on: foot-and-mouth disease control in

Bali; organization of a laboratory service in a developing country; Jembrana disease; reproductive disorders in cattle, Bali/Sumbawa; reproductive disorders in cattle, South Sulawesi; internal and external parasites of cattle and buffaloes; reproductive disorders in livestock in Sri Lanka; and tick-borne diseases in Tanzania.

In the seminar emphasis was placed on the importance of applying epidemiological and economic principles in veterinary development, on the need to create the necessary training institutions and to train staff for this purpose, since at present both are inadequate.

First national seminar on cattle parasites, Brazil

The above seminar, under the auspices of the Brazilian Corporation of Agricultural and Livestock Research (EMBRAPA) and through its National Centre for Research in Beef Cattle (CNPGC) and National Programme of Animal Health Research, was held at Campo Grande, Mato Grosso do Sul, Brazil, in July 1979.

Dr A.G. da Silva, representing the President of EMBRAPA, opened the seminar. The opening was followed by an inaugural address on the development of animal parasitology in Brazil given by Professor P. Cabral

Gonçalves of the Federal University of Rio Grande do Sul.

The objectives of the seminar were to examine the position in Brazil of parasitism affecting cattle, to co-ordinate the activities of workers in this field, to promote the exchange of information and to assist in the standardization of methodologies.

During the week of the seminar panels of specialists from Brazil, Colombia and Paraguay discussed the various aspects of the biology, epidemiology, control and cost/benefits of helminthiasis, fascioliasis, ixodidosis, babesiosis, anaplasmosis, dermatobiosis and miasis.

Some 300 participants attended the seminar, the proceedings of which are to be published by EMBRAPA and will be obtainable from Centro Nacional de Pesquisa de Gado de Corte, Caixa Postal 154, 79100 Campo Grande, MS, Brazil.

Brazilian College of Veterinary Parasitology

During the first national seminar on cattle parasites reported above, the Brazilian College of Veterinary Parasitology was founded, Dr A.A.H. Beck being elected its first President.

The objectives of the new association are to bring

together veterinary parasitologists in a professional body where scientific and professional experiences can be exchanged and the interests of those engaged in this field protected and strengthened.

On the occasion of the XVII Brazilian congress of veterinary medicine, to be held in October 1980 at Fortaleza, Ceará, a new Board of Directors of the College will be elected.

Professional specialists in this field interested in joining the new College are invited to contact Dr A.A.H. Beck, Centro Nacional de Pesquisa de Gado de Corte, Caixa Postal 154, 79100 Campo Grande, MS, Brazil.

FAO Expert Consultation on Research on Trypanosomiasis

The above Consultation was held in Rome from 1 to 5 October 1979. It was attended by 13 specialists from Belgium, Gambia, Italy, Kenya (3), Nigeria, Senegal, Togo, United Kingdom (3) and Upper Volta. Representatives from WHO were present, as were observers from inter-governmental organizations (OAU/IBAR and OIE); international research organizations (ILCA (3) and ILRAD); technical aid administrations and research institutes and from national pharmaceutical industries.

The objectives of the Consultation were to review the

present state of knowledge, evaluate current research programmes, identify needs for new research activities and related training and advise on the co-ordination and funding of research on animal trypanosomiasis. (The review included tsetse-borne trypanosomiasis and the rearing of trypanotolerant livestock but excluded considerations of vectors and transmission of the disease.)

Recommendations were made by the Consultation on research priorities regarding diagnostic techniques, epizootiological surveillance and chemotherapy; pathology and immunology and trypanotolerance and the breeding of trypanotolerant livestock. Other recommendations concerned the strengthening of Africa-based institutes, training needs and scientific literature.

An encouraging feature of the Consultation was the general appreciation of the increasing importance of finding solutions to the problem



FAO money and medals programme

Last year Italy participated in the above programme with the issue of 100 million 100-Lire coins having legal tender throughout Italy.

The FAO coin, illustrated here, bears on its obverse a contemporary representation of Ceres, the Roman goddess of agriculture, thus highlighting FAO's work for rural women's advancement. The reverse shows a Chianina cow — the best-known of the Italian cattle breeds — suckling her calf.

of drug resistance and therefore of the need to increase research on drugs.

The final report will be published in English and French and will be available early in 1980.

Fourteenth Annual Conference on Livestock and Poultry in Latin America

This Conference is to be held at the University of Florida, Gainesville, USA, from 11 to

16 May 1980 and will be held in Spanish. It will be preceded by the Dairy Cattle Short Course (6 to 7 May) and the Beef Cattle Short Course (7 to 9 May), which will be in English.

No advance enrolment is necessary but participants have to make their own hotel reservations.

Technical Consultation on Animal Genetic Resources, Conservation and Management

This Consultation will be held at the Rome headquarters of FAO from 2 to 6 June 1980.

The main purpose of this important meeting is to draw up recommendations concerning, and to ensure the protection of, the world's livestock resources.

Individual papers presented will be published as proceedings under the auspices of FAO and UNEP together with the Consultation's recommendations.

PUBLICATIONS

Slaughter facilities for tropical conditions: a guide to the selection and costing of appropriate systems

By D. EDWARDS, D.A. HECTOR, G.A. NORMAN and D. SILVER-SIDE. Tropical Products Institute, 56/62 Gray's Inn Road, London WC1X 8LU, United Kingdom. Document G-123. 1979. 63 pages. Price: £ 1.52.

This report is intended for those concerned with the upgrading and expansion of slaughter facilities in tropical countries. It is designed to facilitate investment decision making, the basis of the report being a series of physical and financial cost models.

For purposes of analysis, factor costs pertinent to a particular developing country have been applied, but the physical requirements of the models have been set out so that users of the report may apply factor costs appropriate to their own locality.

The report includes chapters on the development of the cost models and the financial analysis of the abattoirs. In the latter chapter a way to analyse the financial performance of the cost models is discussed. This shows how appropriate slaughter fees can be derived from knowledge of the costs of establishing and operating a slaughter facility.

A major part of the report is contained in appendices, which include: tables showing details of cost models developed at four scales of throughput expressed in terms of livestock units; notes concerning the technical aspects of the models; items of equipment for each of the models; and a list of manufacturers of abattoir equipment.

Many developing countries are in the process of improving and expanding their slaughter and abattoir facilities. For such countries, this book can be of the greatest assistance. Before compiling their report the authors consulted FAO regarding FAO publications in

this field in order to avoid any overlapping or duplication of effort. The result is that the reader will find the whole subject comprehensively covered in a thoroughly practical and commonsense way if he reads this publication of the Tropical Products Institute together with FAO Animal Production and Health Paper No. 9: *Slaughterhouse and slaughterslab design and construction*.

DEF

Yoghurt. Scientific grounds, technology, manufacture and preparations

By J. LJ. RAŠIĆ and J.A. KURMANN. Published by the authors. Distributed by Technical

Dairy Publishing House, Jyllingevej 39, DK-2720 Vanløse, Copenhagen, Denmark. Vol. 1. 1978. 460 pages, with 180 illustrations.

As the authors themselves say, this book was prepared to present reliable facts on the microbiology, chemistry, nutritive value and manufacture of yoghurt and related products. The book is divided into eight parts and includes chapters on the history and growth of consumption of yoghurt and related fermented milks; the characteristics of the essential yoghurt organisms and their biochemical activities during lactic acid fermentation; effects of yoghurt cultures and processing on flavour, aroma, consistency and viscosity; the nutritional, physiological value of yoghurt; manufacturing procedures and equipment; development of new products; and the defects of yoghurt and its quality control. A series of appendixes completes the book and provides first-hand information on international standards for yoghurt.

This book may be considered the first complete publication on this important subject. Anyone interested and concerned with the subject, whether students or technicians specialized in production or quality control, will find the answers to any question they may have as well as solutions to their technical problems in this book.

Volumes 2 and 3 dealing with other fermented milks are now in course of preparation.

JR

Bibliography of tropical apiculture

By E. CRANE. International Bee Research Association, Hill House, Gerrards Cross, Bucks. SL9 0NR, UK. Bound volume with author index. Price: US\$ 68.

This publication, funded by the International Development Research Centre of Can-

ada and prepared at the International Bee Research Association (IBRA) in the United Kingdom, provides a compact key to several thousand publications accessible through the IBRA Library. It gives information on some 140 countries and is divided conveniently into 24 parts.

There is an enormous unexploited beekeeping potential in tropical countries, which are now standing at the threshold of a beekeeping expansion as great and far-reaching as occurred in the countries of the temperate zones 120 years ago when movable-frame beekeeping was being taken up country by country. In India, for example, plant resources could support 50 million hives but at present there are only a half million. In Ethiopia, which has an especially rich beekeeping tradition, only 30 of that country's beekeepers, who have some 3 million hives, use modern frame-hives.

Beekeeping utilizes nectar and pollen resources that otherwise go to waste and requires little or no land. Until now one of the greatest hindrances to development has been the lack of co-ordinated knowledge that would provide the necessary foundation on which sound development plans could be built. This bibliography will go far toward meeting this need.

DEF

Livestock development programmes for the Asian small farmer

Australian Veterinary Association, 134-136 Hampden Road, Artarmon, NSW 2064, Australia. 1979. 35 pages.

This publication presents the proceedings of a seminar held at the 1978 Annual Conference of the Australian Veterinary Association.

In Asia alone some 400 million people depend for their subsistence largely on rainfed agriculture; there, as

elsewhere, the urgent need is to provide assistance in order to improve the living conditions of the small farmer.

Although in most of the countries concerned livestock accounts for a relatively low proportion of the gross value of agricultural production it does form an integral part of the rural economy, providing a significant source of cash income and a capital reserve for the farmer at times of crop failure.

The seminar clearly aroused considerable interest. A number of excellent papers were presented describing the varied conditions in Fiji, India, Indonesia, Malaysia, Nepal, Philippines, Singapore and Thailand. The papers contain a great deal of valuable information concerning the problems of the small farmer and the efforts being made to develop his livestock activities.

The papers consistently justify the livestock development policies of individual countries on the grounds of ensuring adequate production to meet the needs of the population for livestock products, diversifying production, creating employment and reducing under-employment and assisting the small farmer in improving his standard of living.

There was general agreement that the main constraints on increasing livestock production of the small farmer were the lack of markets, credit, inputs and services, sociological problems such as those related to land tenure systems and the lack of trained personnel to assist in the application of appropriate technology, emphasis being placed on the word "appropriate".

The provision of markets to provide adequate returns for farm products was stressed as the first priority; without adequate outlets for farm produce, other improvement programmes are likely to fail through lack of incentive.

Many papers stressed the importance of disease control

and prevention, and the improvement of animal nutrition. In the latter case the need for forage crop seed-distribution schemes and improvement of the (mainly) communal pastures was stressed. The great values of feed-mixing and -milling plants in providing balanced feed-concentrates for milk, poultry and pig production were also underlined.

There was general agreement that while advanced technology from developed countries was applicable in processes such as vaccine production and feed mixing, the need at the small-farm level was for technology suitable and acceptable to the small farmer himself.

The Australian Veterinary Association is to be warmly complimented for holding this seminar and publishing its results. The publication provides a concise and most valuable account of the present position of small-farm livestock production in the Asian region.

DEF

Multilingual illustrated animal production dictionary

Steinmetz Dictionaries, D-5240 Betzdorf, Federal Republic of Germany.

This is the third edition of this handy pocket-size (160 × 105 mm) animal production dictionary formerly issued under the title of "Livestock feeding and management".

Subjects are classified to facilitate the finding of the precise term, the table of contents is provided with thumb markers and the text is in six languages: Dutch, English, French, German, Italian and Spanish. A very wide field of animal production is covered including diseases and veterinary science, horse keeping, fish farming, rabbit keeping, forage and pasture plants and commercial feedstuffs — as well as those usually included under this heading. The dictionary is well illustrated and is thus

able to amplify the definitions presented.

This dictionary will be of great value to all those concerned with animal production who need to use any of the languages included.

DEF

Breeding and improvement of farm animals

By E.J. WARWICK and J.E. LEGATES. Published by McGraw-Hill. Distributed by McGraw-Hill, Lademannbogen 136, Postamt 65, Heegbarg 2, D-2000 Hamburg 65, Federal Republic of Germany. Price: DM 57.40.

This is the seventh edition of a book first published in 1926.

The new edition continues to place its main emphasis on the genetic aspects of livestock improvement but the authors take great pains to stress the vital importance of an optimum environment involving efficient feeding and management and high standards of disease control concurrent with the raising of the level of performance through selective breeding.

The seventh edition has been completely revised and updated and includes three new, important chapters:

qualitative genetics in animal breeding; performance and progeny testing; and breeding of horses. The inclusion of the latter chapter reflects the growing interest, in the United States, in breeding horses as a pastime.

The new edition contains not only a new glossary, index and appendix but has, at the end of each chapter, a section containing suggestions for further reading, which replaces the list of references given in the old editions. This section not only contains an up-to-date list of relevant books but also a list of the more important articles that have appeared on the subject in international journals.

This text book will continue to occupy a leading position in the literature as a teaching and reference book for all those interested in livestock production.

CGH

Diseases of feedlot cattle

By R. JENSEN and D.R. MACKEY. Published by Lea and Febiger. Third edition.

This book, although written from United States experi-

ence, provides one of the few references in this field available to those engaged in similar operations elsewhere in the world.

During recent years the tendency in most countries has been for cattle to be fed and finished in feedlots of ever-increasing size. As the authors themselves write, "During the first critical weeks of fattening diets change from predominantly roughage to predominantly concentrate, immunizations and deparasitizations are administered and environments change from open clean pastures to crowded contaminated pens. As a result diseases of the respiratory and digestive tracts are always present and sometimes rampant."

A useful opening chapter on conditioning cattle for the feedlot is followed by well-illustrated chapters describing the diseases caused by viruses, rickettsia and chlamydia, bacteria, fungi, protozoan parasites, metazoan parasites, and those having unknown and miscellaneous causes. A well-prepared index completes the book.

This book is strongly recommended to all those engaged in intensive feeding and

finishing of cattle wherever they may be.

DEF

A colour atlas of the rat — a dissection guide

By R.J. OLDS and J.R. OLDS. Published by Wolfe Medical Publications, 3-5 Conway Street, London W1, United Kingdom. Price: £ 4.00.

This atlas is intended to meet the needs of animal technicians and of secondary school and university students in their first studies of rat anatomy, structure and function. The excellent colour photographs, each accompanied by a concise and clear explanatory text and a key to the tissues and organs shown, should do much to avoid wastage of animals and help in properly preparing the student before he dissects.

DEF

Corrigendum

World Animal Review 33, 1980.

Pages 1 and 14: The editor regrets the misspelling of an author's name. *For* J.D. Berry *read* J.D. Barry

COMMENT

(Continued from front cover)

ment (CEEMAT) in co-operation with the Institute of Tropical Animal Production and Veterinary Medicine (IEMVT). FAO arranged for the translation of the document and its distribution in English. It has already filled a long-felt need, covering as it does a wide range of subjects including the choice, care, use, training and harnessing of animals; the types and use of agricultural implements for animal traction; the animals and their equipment for use in transport and for tasks such as raising water; and the economic aspects of using draught animals.

Two other important FAO publications in the same field are also likely to be in increasing demand in the future. These are *Small farm implements* (Nos. 5 and 32 respectively in the FAO Agricultural Series and Agricultural Development Papers) and the manual *Farming with animal power*, translated and adapted for use at the intermediate level of agricultural education and training from the original published by the Agri-Service Afrique of the Institut africain pour le développement économique et social (INADES).

The article *Animal power in agricultural production systems* in this issue of the *World Animal Review* outlines, with reference to a particular country, the type of problem likely to be encountered and the decisions that will need to be made in other developing countries fortunate enough to possess large numbers of suitable animals and that decide to train and develop them for draught power.

Needless to say, FAO stands ready to assist governments in the planning and development of projects and programmes designed to promote and develop the use of draught animals.

Information for contributors

We welcome letters from writers suggesting ideas and subjects for articles.

Articles for the World Animal Review should normally be of a review or report nature and should be practical and informative. However, research results, when appropriately presented, may also be acceptable. Articles on the application of new ideas, work, equipment and methods will be particularly welcome, especially when they are of direct interest and of particular value to agricultural and animal scientists in developing countries.

Preparation of manuscripts

Manuscripts are accepted in English, French or Spanish. The Oxford English Dictionary is used as a standard for English spelling.

As far as possible the form and terminology used in articles should be straightforward and simple. Abbreviations or acronyms should be defined. Each article should be typed double-spaced on quarto paper (approximately 28 × 22 cm or 11.0 × 8.5 inches) on one side of the page leaving margins of 5 cm (2 inches). One or two levels of headings should be sufficient for most articles.

Length of manuscript

Articles should normally be 3 000-4 000 words in length, excluding tables and figures, with a maximum of 5 000 words for special articles. Important communications shorter than this are acceptable.

Tables, figures, graphs, photographs

These should each be on a separate page, numbered to correspond to their points of reference in the text, well spaced for printers' instructions to be inserted clearly, and with their sources identified. Graphs and diagrams should be clearly drawn in black Indian ink on thick, smooth white paper or on thin, smooth white board. Measurements should be in the metric system.

Negatives, photographs or slides are preferred but, where these cannot be supplied, photographs should be black-and-white, clear of full contrast and on glossy bromide paper.

Graphs, diagrams and photographs should be at least 13 × 18 cm (5.0 × 7.0 inches) and should be captioned on the back. Articles should normally be illustrated with four to six photographs and/or diagrams.

Please do not fold material. Send it suitably supported by cardboard in the envelope or package.

References and bibliography

The published work of other authors quoted in the text should normally be given a date in brackets after the author's name. This reference should be given in the list of references at the end of the article in the following order: author and initials; year; title of article/paper; title of journal; volume; part in brackets and page numbers. References should be in alphabetical order. Abbreviations of journal titles

should, if possible, be those given in "The World List of Periodicals". References should be selected and normally restricted to 5-10 separate items. All references should be specifically referred to in the text.

The use of footnotes should be avoided as far as possible.

Republished articles

We prefer original articles but we do not rule out reprints, especially where these may give rise to the exchange of views and experience of development between animal production and health readers in developed and developing regions of the world.

Publication by FAO

The decision of FAO is final on all matters regarding the editing and publication of articles. FAO cannot be bound to publish manuscripts. If an article is not accepted the author is free to publish elsewhere. Copyright and other proprietary rights with respect to manuscripts, with the exception of any material already subject to copyright or other proprietary rights, shall be vested in the author, who grants FAO licence to publish and reprint. The author must specify any material contained in the manuscript (including illustrations, diagrams and graphs) that is already subject to copyright or some other proprietary right, and must warrant that he has obtained authorization to use such material from the owner(s) or their legal representatives.

Reprints

Upon publication, 25 free copies of the journal containing the author's article will be sent to him. If reprints are required of articles (or of the issue in which they are contained) these should be ordered at the time of submitting the typescript. The cost of reprints to authors will depend on the length of the article ordered. An estimate of the cost of an order should be requested at the time the article is submitted. An issue of the Review costs contributors 62.5 US cents per copy (air postage extra).

Address for correspondence

Technical Editor, World Animal Review, Animal Production and Health Division, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

Who are the readers?

FAO's World Animal Review is prepared in the Animal Production and Health Division and is directed primarily at assisting developing countries in their livestock industry. It is read by planners and technical and scientific staff in government departments, universities, research institutes, colleges, training centres, on projects and by extension officers in the field; by specialist and technical personnel of multilateral and bilateral agencies; by a considerable number of organizations and editors of professional and trade journals; and by scientists and individuals in developed and developing countries.

FAO SALES AGENTS AND BOOKSELLERS

Algeria
Antilles, Netherlands
Argentina
Australia

Austria
Bangladesh
Belgium
Belize
Bolivia

Brazil

Canada
Chile
China
Colombia
Costa Rica
Cuba
Cyprus
Denmark
Dominican Rep.
Ecuador
El Salvador
Finland
France
Germany, F.R.
Ghana
Greece
Guatemala
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy

Jamaica
Japan
Kenya
Korea, Rep. of
Kuwait
Luxembourg
Mauritius
Mexico
Morocco
Netherlands
New Zealand

Nicaragua
Nigeria
Norway
Pakistan
Panama
Paraguay
Peru
Philippines
Poland
Portugal

Romania
Saudi Arabia
Senegal
Somalia
Spain
Sri Lanka
Suriname
Sweden
Switzerland
Tanzania
Thailand
Togo
Trinidad and Tobago
Tunisia
Turkey

United Kingdom

United States of America

Uruguay
Venezuela

Yugoslavia

Other countries

Société nationale d'édition et de diffusion, 3, boulevard Zirout-Youcef, Algiers.
St. Augustinus Boekhandel, Abraham de Veerstraat 12, Willemstad, Curaçao.
Editorial Hemisferio Sur S.R.L., Librería Agropecuaria, Pasteur 743, Buenos Aires.
Hunter Publications, 58A Gipps Street, Collingwood, Vic. 3066; The Assistant Director, Sales and Distribution, Australian Government Publishing Service, P.O. Box 84, Canberra, A.C.T. 2600; and Australian Government Publications and Inquiry Centres in Canberra, Melbourne, Sydney, Perth, Adelaide and Hobart.
Gerold & Co., Buchhandlung und Verlag, Graben 31, 1011 Vienna.
Agricultural Development Agencies in Bangladesh, P.O. Box 5045, Dacca 5.
Service des publications de la FAO, M.J. De Lannoy, 202, avenue du Roi, 1060 Brussels. CCP 000-0808993-13.
The Belize Bookshop, P.O. Box 147, Belize.
Los Amigos del Libro, Perú 3712, Casilla 450, Cochabamba; Mercado 1315, La Paz; René Moreno 26, Santa Cruz; Junín esq. 6 de Octubre, Oruro.
Livraria Mestre Jou, Rua Guaipá 518, São Paulo 10; Rua Senador Dantas 19-5205/206, Rio de Janeiro; PRODIL, Promoção e Dist. de Livros Ltda., Av. Venâncio Aires 196, Caixa Postal 4005, Porto Alegre, RS; Livraria Dom Bosco, Rua 14 de Julho 2818, Caixa Postal 962, Campo Grande, MT; A NOSSA LIVRARIA, CLS 103, Bloco C, Lojas 2/6, Brasília, D.F.; FIMAC, Distribuidora de Livros Ltda., Rua de Bahia 478, Loja 10, Belo Horizonte, ME; METRO CUBICO, Livros e Revistas Técnicas Ltda., Praça São Sebastião, Rua 10 de Julho 613, Caixa Postal 199, Manaus, Amazonas; Distribuidora Luso Mercantil, Rua 13 de Maio 524, Caixa Postal 1124, Belém, Pará; G. Lisboa Livros Ltda., Rua Princesa Isabel 129, Recife, PE; Livraria Cometa Distribuidora Ltda., Rua da Independência 46, Salvador, Bahia.
Renouf Publishing Co. Ltd., 2182 Catherine St. West, Montreal, Qûe. H3H 1M7.
Tecnolibro S.A., Merced 753, entresol 15, Santiago.
China National Publications Import Corporation, P.O. Box 88, Peking.
Litexsa Colombiana Ltda., Calle 55, N° 16-44, Apartado Aéreo 51340, Bogotá.
Librería, Imprenta y Litografía Lehmann S.A., Apartado 10011, San José.
Empresa de Comercio Exterior de Publicaciones, O'Reilly 407, Havana.
MAM, P.O. Box 1722, Nicosia.
Ejnar Munksgaard, Norregade 6, Copenhagen S.
Fundación Dominicana de Desarrollo, Casa de las Gárgolas, Mercedes 4, Santo Domingo.
Su Librería Cia. Ltda., Garía Moreno 1172, Apartado 2556, Quito; Calle Chimborazo 416, Guayaquil.
Librería Cultural Salvadoreña S.A., Calle Arce 423, Apartado Postal 2296, San Salvador.
Akateeminen Kirjakauppa, 1 Keskuskatu, Helsinki.
Editions A. Pedone, 13, rue Soufflot, 75005 Paris.
Alexander Horn Internationale Buchhandlung, Spiegelgasse 9, Postfach 3340, Wiesbaden.
Fides Enterprises, P.O. Box 1628, Accra; Ghana Publishing Corporation, P.O. Box 3632, Accra.
"Eleftheroudakis", 4 Nikis Street, Athens.
Distribuciones Culturales y Técnicas « Artemis », Quinta Avenida 12-11, Zona 1, Guatemala City.
Conselho Nacional de Cultura, Avenida da Unidade Africana, C.P. 294, Bissau.
Guyana National Trading Corporation Ltd., 45-47 Water Street, Georgetown.
Max Bouchereau, Librairie « A la Caravelle », B.P. 111, Port-au-Prince.
The Bookstore, Apartado Postal 167-C, Tegucigalpa.
Swindon Book Co., 13-15 Lock Road, Kowloon.
Snaebjörn Jónsson and Co. h.f., Hafnarstraeti 9, P.O. Box 1131, Reykjavik.
Oxford Book and Stationery Co., Scindia House, New Delhi; 17 Park Street, Calcutta.
P.T. Gunung Agung, 6 Kwitang, Djakarta.
Iran Book Co. Ltd., 127 Nadershah Avenue, P.O. Box 14-1532, Tehran.
National House for Publishing, Distributing and Advertising, Rashid Street, Baghdad.
The Controller, Stationery Office, Dublin.
Emanuel Brown, P.O. Box 4101, 35 Allenby Road and Nachlat Benyamin Street, Tel Aviv; 9 Shlomzion Hamalka Street, Jerusalem.
Distribution and Sales Section, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome; Libreria Scientifica Dott. L. De Biasio "Aeiou", Via Meravigli 16, 20123 Milan; Libreria Commissionaria Sansoni "Licosa", Via Lamarmora 45, C.P. 552, 50121 Florence.
Teacher Book Centre Ltd., 95 Church Street, Kingston.
Maruzen Company Ltd., P.O. Box 5050, Tokyo Central 100-31.
Text Book Centre Ltd., P.O. Box 47540, Nairobi.
The Eul-Yoo Publishing Co. Ltd., 5 2-Ka, Chong-ro, Seoul.
Saeed & Samir Bookstore Co. Ltd., P.O. Box 5445, Kuwait.
Service des publications de la FAO, M.J. De Lannoy, 202, avenue du Roi, 1060 Brussels (Belgium).
Nalanda Company Limited, 30 Bourbon Street, Port Louis.
Dilitsa S.A., Puebla 182-D, Apartado 24-448, Mexico City 7, D.F.
Librairie « Aux Belles Images », 281, avenue Mohammed V, Rabat.
N.V. Martinus Nijhoff, Lange Voorhout 9, The Hague.
Government Printing Office: Government Bookshops at Rutland Street, P.O. Box 5344, Auckland; Alma Street, P.O. Box 857, Hamilton; Mulgrave Street, Private Bag, Wellington; 130 Oxford Terrace, P.O. Box 1721, Christchurch; Princes Street, P.O. Box 1104, Dunedin.
Libreria Interamericana Nicaragüense S.A., Apartado 2206, Managua.
University Bookshop (Nigeria) Ltd., University of Ibadan, Ibadan.
Johan Grundt Tanum Bokhandel, Karl Johansgt. GT 41-43, Oslo 1.
Mirza Book Agency, 65 The Mall, Lahore 3.
Distribuidora Lewis S.A., Edificio Dorasol, Calle 25 y Avenida Balboa, Apartado 1634, Panama 1.
Agencia de Librerías Nizza S.A., Paraguarí 144, Asunción.
Librería Distribuidora Santa Rosa, Jirón Apurímac 375, Casilla 4937, Lima.
The Modern Book Company, 928 Rizal Avenue, Manila.
Ars Polona-Ruch, Krakowskie Przedmiescie 7, Warsaw.
Livraria Bertrand, S.A.R.L., Apartado 37, Amadora; Livraria Portugal, Dias y Andrade Ltda., Apartado 2681, Rua do Carmo 70-74, Lisbon-2; Edições ITAU, Avda. República 46A c/v-E, Lisbon-1.
Illexim, Calea Grivitei N° 64-66, B.P. 2001, Bucarest.
University Bookshop, Airport Road, P.O. Box 394, Riyadh.
Librairie Africa, 58, avenue Georges Pompidou, B.P. 1240, Dakar.
"Samater's", P.O. Box 936, Mogadishu.
Mundi Prensas Libros S.A., Castelló 37, Madrid-1; Librería Agrícola, Fernando VI 2, Madrid-4.
M.D. Gunasena and Co. Ltd., 217 Norris Road, Colombo 11.
VACO nv in Suriname, P.O. Box 1841, Domineenstraat 26/32, Paramaribo.
C.E. Fritzes Kungl. Hovbokhandel, Fredsgatan 2, 103 27 Stockholm 16.
Librairie Payot S.A., Lausanne et Genève; Buchhandlung und Antiquariat, Heinemann & Co., Kirchgasse 17, 8001 Zurich.
Dar es-Salaam Bookshop, P.O. Box 9030, Dar es-Salaam.
Suksapan Panit, Mansion 9, Rajadamnern Avenue, Bangkok.
Librairie du Bon Pasteur, B.P. 1164, Lomé.
The Book Shop, 111 Frederick Street, Port of Spain.
Société tunisienne de diffusion, 5, avenue de Carthage, Tunis.
Güven Bookstores, Güven Bldg., P.O. Box 145, Müdafaa Cad. 12/5, Kizilay-Ankara; Güven Ari Bookstores, Ankara Cad. No. 45, Cağaloğlu-Istanbul; Güven Bookstore, S.S.K. Konak Tesisleri P-18, Konak-Izmir.
Her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB (callers only); P.O. Box 569, London SE1 9NH (trade and London area mail orders); 13a Castle Street, Edinburgh EH2 3AR; 41 The Hayes, Cardiff CF1 1JW; 80 Chichester Street, Belfast BT1 4JY; Brazenose Street, Manchester M60 8AS; 258 Broad Street, Birmingham B1 2HE; Southey House, Wine Street, Bristol BS1 2BQ.
UNIPUB, 345 Park Avenue South, New York, N.Y. 10010; mailing address: P.O. Box 433, Murray Hill Station, New York, N.Y. 10016.
Librería Editorial Juan Angel Peri, Alzaibar 1328, Casilla de Correos 1755, Montevideo.
Blume Distribuidora S.A., Av. Rómulo Gallegos esq. 2a. Avenida, Centro Residencial « Los Almendros », Torre 3, Mezzanina, Ofc. 6, Urbanización Montecristo, Caracas.
Jugoslovenska Knjiga, Terazije 27/11, Belgrade; Cankarjeva Založba, P.O. Box 201-IV, Ljubljana; Prosveta Terazije 16, P.O. Box 555, 11001 Belgrade.
Requests from countries where sales agents have not yet been appointed may be sent to: Distribution and Sales Section, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.